COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

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PNEUMATIC TOOLS CLEANING STEEL SURFACE

The half tone herewith tells its own story, and requires scarcely a word of explanation. It shows half a dozen men using "Imperial" pneumatic scaling hammers on the side of the Alaska of the Hawaiian Steamship Company as she lies at her dock in New York harbor.

The advent of the "pneumatic tool" in its various forms, as adapted to different classes of work, has resulted in the development of new trades or specialized lines of industry. As here indicated, a pushing firm of contractors have fitted up a scow or float with the necessary apparatus and stand constantly ready to take jobs such as here shown of cleaning the exposed surfaces of steamers from old paint, scale and rust and then repainting them. In connection with this work divers are furnished who can use the same or similar tools under water for removing barnacles or incrustations which as they accumulate materially reduce the running speed and entail extra pull on the coal bunkers.

The advantage to the ship owner by this

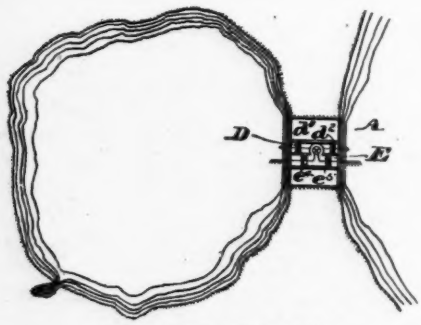
PNEUMATIC TOOLS CLEANING A STEAMER'S SIDES.

arrangement is important. The time and expense of dry-docking are saved and the work as here shown is not only more cheaply done but it may almost entirely be accomplished while loading or unloading is going on.

TIDAL AIR COMPRESSION

By W. O. Webber.

Along the coast of Maine a large number of tidal basins exist. The same is largely true of the coast lines in the balance of the United States and of other countries in the temperate zones. If we place a dam across the outlets



TIDAL BASIN WITH DAM.

of either of these coastal indentations, holding the water in a so-called mill pond, the outflow and inflow can be utilized in the manner here to be described:

Fig. 1 is a plan of the inlet and outlet passageways, with the necessary gates. Fig. 2 is a vertical section on the line 2-2 of Fig. 1. Fig. 3 is an enlarged vertical elevation on the lines 3-3 of Fig. 1.

1 is the inlet passageway, 2 is the outlet passageway, 3 is the longer leg and 4 the shorter leg of an inverted siphon connecting the inlet and outlet passageways. The grade of the bottom of the outlet passageway 2 is below that of the inlet passageway 1. 4 is preferably made of a larger area than 3. 5 and 5*a* are inwardly opening gates situated in the inlet passageway, and 6 and 7 are outwardly opening gates situated in the outlet passageway. 8 is an enlarged separating chamber, situated at the bottom of the inverted siphon, and 9 is an abutment wall transversely situated in said chamber. 10 are pontoons situated in the inlet passageway 1, carrying fulcrums 11, on which are pivoted weighted levers 12. One end of these levers is pivoted to beams 13, which support transversely disposed beams 14, which, in turn, support downwardly depending air pipes 15. These air pipes are adjustably located by the collars 16. Upon the side of the inlet pas-

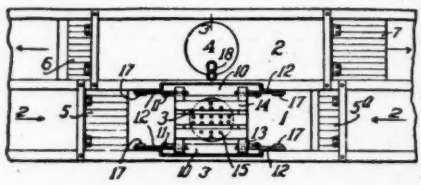


Fig. 1

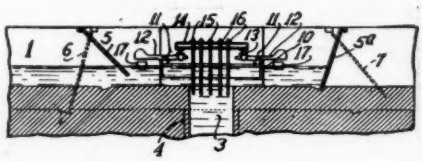


Fig. 2

sageway 1 are located stop blocks 17. Rising from the upper part of the separating chamber 8 is a service pipe 18, provided with a stop valve 19.

The operation is as follows:

These two passageways are transversely disposed through a dam which spans the neck of a tidal basin. If, now, we assume that the water impounded in a tidal basin enters the inlet passageway 1, from the left, as shown by the arrows, it will automatically swing open the inlet gate 5, pass down the long leg of the siphon 3, and in passing in and around the vertically depending air pipes 15 entrain air with the water. The descending column of air and water then impinges upon the transversely disposed abutment wall 9, at the bottom of the

siphon, which causes the air to be rapidly freed from the water. This air then is caught and held by the pocket, or air chamber 8, while the water passes around the ends of the abutment wall 9, and thus into the shorter and larger leg of the siphon 4, then flows upward into the outlet passageway 2, forcing open the gate 7 and passing into the ocean, the gate 5*a* in the inlet passageway and the gate 6 in the outlet passageway being held tight by the pressure of water against them.

Upon the reversal of the tide, so that it flows

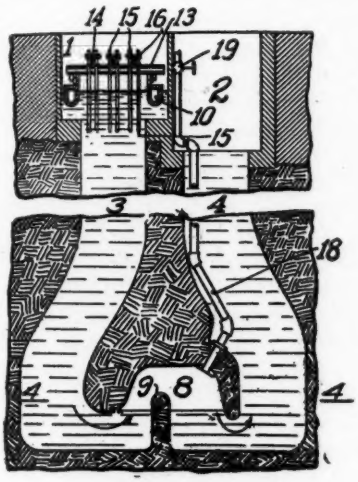


FIG. 3

from the right into the inlet passageway 1, the gate 5*a* is automatically forced open, the gate 5 is shut, the water and entrained air flow down the longer leg of the siphon, as before, up the shorter leg, and, shutting the gate 7, force open the gate 6, thereby emptying into the tidal basin.

As the water falls in either the tidal basin or the ocean the water will correspondingly fall in the inlet passageway 1, and the air inlet pipes will descend as the level of the water falls in the inlet passageway, thus maintaining the lower ends of these inlet pipes at a constant depth below the surface of the water in the inlet passageway. This would continue until the flotation tanks 10 rested upon the bottom of the passageway, when any further fall of the water would vary the submersion. To overcome this, just before the bottom of the flotation tanks would strike the bottom of the inlet passageway, the outer ends of the levers 12 are brought into contact with the stops 17, causing the frame carrying the inlet pipes to descend at a faster rate, in proportion to the leverage, thus obtaining an increased rate of submersion at the lower depth of water in the inlet passageway. This mechanism will result in this apparatus continuing in an operative state with a very small difference in the level of the tide, and it also provides an automatically starting, stopping and operative device.

POWER COSTS.

The cost of a horse-power from steam engines of large capacity (say a thousand horse-power or over) on a ten-hour basis three hundred and eight days in a year, with coal at $3 per ton, is $23.25. This is equal to $46 per year on a twenty-four-hour basis three hundred and sixty-five days in the year.

An electrical horse-power on the latter basis, directly at the place of generation and obtained from falling water, costs $15.24. Our hydraulic compressed air horse-power at the dam costs $8.25, or about one-half the cost of electric power, and one-third the cost of steam power.

Our air power transmitted by a pipe line to a point four miles from its source costs $9.05, and electrical power transmitted four miles costs $16.49. At a distance of twenty miles from a source, air power costs $13.15 and electric power $19.21.

Small consumers of steam can afford to pay anything less than one-half of the following tabulated figures for air under pressure to use in their engines, as in these figures practically one-half the cost is fuel and the other half general expense, maintenance, attendance, etc.

	Cost of 1 H. P. 365 days 24 hrs. coal per 2240 lbs.				Cost of 1 H. P. 308 days 10 hrs. coal per 2240 lbs.			
	$2	$3	$4	$5	$2	$3	$4	$5
Triple expansion pump, Allis, 20 revolutions	48	55	61	67	31	33	35	37
Triple expansion pump, Allis, 50 revolutions	27	33	39	45	16	18	20	22
Compound mill, best	29	36	44	52	17	19	21	24
" " average	39	47	52	58	22	25	28	30
" " electric light average	122	130	137	174	78	84	90	96
" " trolley	48	58	68	79	29	32	36	39
Triple expansion trolley	45	54	64	74	26	29	33	36
Condensing mill	44	52	61	69	25	29	33	38
Non-condensing mill, 50 to 200	70	76	81	88	49	53	57	62

TABLE OF STEAM POWER COSTS.

A further discussion of this means of obtaining power and the tests made on such plants may not be uninteresting.

MOISTURE IN AIR.

Air compressed by the ordinary methods of mechanical compression contains at least the

same amount of moisture as the surrounding atmosphere from which it was compressed; and in parting with the heat necessarily contributed to the air by mechanical compression there is incidentally a considerable loss of energy. Air compressed directly by falling water is kept at the same temperature as this water. It is compressed isothermally, and the consequent expansion, when used in motors, produces an almost truly adiabatic expansion line. Tests, however, have shown that air compressed in this manner contains only one-sixth of the moisture originally in the surrounding atmosphere from which it is compressed. This is probably because the moisture in the bubble of air is pressed or squeezed out to its surface and then absorbed by the surrounding water. Incidentally there is no loss of power in parting with any heat, and there is a practical result which is of more importance—the hydraulically compressed air can be expanded in use down to a temperature much below the freezing point, while atmospheric air, with the usual amount of moisture, mechanically compressed, often cannot be used at all, owing to the freezing up of the exhaust passages of the motor in which the attempt to use it is being made.

ADAPTABILITY.

The adaptability of compressed air for various uses is very great. While electricity supplies power and light very directly, it cannot be used for heating except at a prohibitive cost. Gas is used very directly to supply heat, power and light, but is expensive for heating and power at the prices generally charged. City water pressure can be used to supply power, and indirectly light, by the use of a water motor driving a dynamo, but is too expensive for most purposes. Steam supplies heat and motive power almost directly, and indirectly light through a dynamo. It is, however, more expensive than compressed air, and involves more risk and attention. Compressed air can be used directly as a source of motive power, ventilation and refrigeration, also in the operation of elevators. It is particularly advantageous to use in storehouses and warehouses for the operation of the elevators and any other machinery which it may be desirable to locate in such a building, owing to the fact that there would be no danger of its freezing up and there would be no necessity of keeping the building warm in consequence, and also from the fact that there would be no fire risk due to pipes coming in contact with woodwork, as might be the case if steam pipes were used.

In fact, with enclosed self-oiling bearings, compressed air would offer the only practical power which might be used in the interior of a powder magazine.

Air has been transmitted for considerable distances and under a great range of pressures. At the Mont Cenis Tunnel, air was transmitted to the boring machinery 20,000 feet, under a pressure of 105 pounds per square inch. In the installation at Paris in 1881, by M. Popp, the length of the pipes slightly exceeded twenty-four miles, the main is a steel pipe 20 inches in diameter, and the air, maintained at 90 pounds pressure, transmits 6,000 horse-power.

At Offenbach, near Frankfort-on-the-Main, air is distributed through 25,000 feet of cast iron pipe under 90 pounds pressure. At the Portsmouth Dock Yards, England, air is transmitted through 14,000 feet of pipe, varying from 3 to 12 inches in diameter, under 60 pounds pressure, and is used to drive forty 7-ton capstans, five 20-ton cranes and machinery for working seven caissons.

There is also a large compressed air plant at the Terni Steel works in Central Italy. In this plant 1,200,000 feet of air per day, under 75 pounds pressure, are used to drive a 100-ton hammer, a 100- and 150-ton crane and numerous engines.

In this country 2,500,000 cubic feet of air per day, at 60 pounds pressure, delivering 1,700 horse-power, are used at the Chapin mines in Michigan. The mains in this plant are 24-inch wrought-iron pipes, one-quarter inch thick. Very successful compressed air tramways have been operated for a number of years at Berne, Switzerland, and at Nantes, France.

We have already mentioned its use in connection with power hammers, cranes and motors. For drying purposes it is even more efficient than heat. Compressed air is also largely susceptible to double uses. For instance, after it has been used cold, or without preheating expansively in a motor to produce power, the exhaust furnishes an efficient and cheap method of producing refrigeration.

In the transmission of compressed air over long distances, the loss of pressure due to fric-

tion in pipes of proper sizes, and the loss due to leakage in properly constructed pipes and joints are very small. Velocities of from 30 to 50 feet per second are allowable. When an air distribution system is introduced into a thickly settled community, the safety from the air main is very much greater than from a steam main or a water main under pressure and the leakage or even the bursting of such a pipe is attended with very much less damage.

Another great advantage in such a case is that power users require no new plant, and need incur no outlay for motors. Their present steam engines, with little or no alteration, are admirably adapted for serving as air motors.

Tests of small motors of from one to two horse-power, using air at the ordinary atmospheric temperature and at 735 pounds per square inch absolute, exhausting at from 33 degrees to 54 degrees, required a consumption of 1,200 cubic feet of air per brake horse-power per hour. At the Berne tramway the air is compressed to 450 pounds per square inch. On the average the cars use about 35 pounds of air per car-mile. This, however, is used in connection with hot water. In small motors of from one to two horse-power, with the air pre-heated to a temperature of about 158 degrees and exhausting at about the freezing point, or 32 degrees, 850 cubic feet of air per brake horse-power per hour were used.

In some very carefully conducted trials made by Professor Riedler, using an 80 horse-power engine which was actually giving 72 indicated horse-power, using air at 80 pounds pressure, heated to 320 degrees, with cylinders jacketed with hot air and exhausting at about 95 degrees, about 425 cubic feet of air per brake horse-power per hour were used. This showed an efficiency of about 92 per cent.

During some tests made at Magog in September, 1899, owing to the condition under which these tests were made, the change in the humidity on the air was not so great as above stated. The moisture in the external air showed 90 per cent. of saturation, and after compression 29 per cent., or a little more than one-quarter. In the Magog tests, using an old 75 horse-power Corliss engine, with air at 53½ pounds gage pressure, with cold air direct from the compressor at from 66 degrees to 73 degrees and exhausting down to the extremely low point of 42 degrees below zero, 850 cubic feet of air per brake horse-power per hour were used; and with the air preheated to from 205 degrees to 295 degrees Fahrenheit, and exhausting at from 67 degrees to 68 degrees, 620 cubic feet of air per brake horse-power per hour were used.

These figures show conclusively that while water power for direct consumption at the site of the waterfall is the cheapest known form of power, yet for transmission purposes, hydraulically compressed air offers a means of transporting power and gives results cheaper than electricity, and that both electrical transmission and compressed air transmission from water powers are cheaper than steam power.

The compressed air transmission also has a further advantage in the fact that in order to utilize it, it is not necessary to go to an expensive outlay for electric motors, as the compressed air can be used directly in steam engines without requiring any alteration to be made in them.

AN ELECTRICAL BAROMETER

An English inventor, Mr. P. B. Goldschmidt, has invented an electrical device by which the fluctuations of the mercury in a barometer are indicated with minute accuracy. A v-shaped carbon filament passes down through the Torricellian vacuum, the apex being submerged in the mercury. The two ends of the filament pass through the glass of the barometer tube at different points and are connected, one with the cathode, the other with the anode of a battery, a galvanometer being in the circuit. If the barometer rises the current has a less length of carbon filament to traverse and the galvanometer shows an increased current, with a reverse effect if the barometer falls, the mercury never falling entirely out of contact.

To eliminate the effect of changes of temperature, a thermometer, provided with a carbon filament in the same way as the barometer is included in the circuit. At each reading a known resistance is added to the circuit sufficient to bring the galvanometer to the null point and from this resistance the height of the barometer can be determined to the tenth of a millimeter (.004 in.)

This Goldschmidt barometer confirms the fact, long-suspected but which the ordinary barometer cannot tell us, that the atmospheric pressure is continually varying, being hardly ever the same for five minutes at a time.

ROCK DRILLS ON THE RAND.

The recently published statistics of the Mines Department show in a striking way how large is the field for rock drills upon the Rand both in stoping and development work. According to these records 66,047 feet of development were accomplished in the producing mines and 16,388 feet in the non-producing mines during the month of July, making a total altogether of 82,435 feet, or, say, near 16 miles. Some 2,210,271 tons of rock were hoisted from all mines. The average number of rock drills in use was 2,868, of which number the producing mines employed no less than 2,655. Large as the figure is, and indicative of the enormous amount of money represented by the air-drill installations of the Rand, it is steadily growing, for only to go as far back as the preceding month of June, there were during that period on all mines on the Rand an average of 2,662 rock drills in use, showing an increase for the month of 206 machines. Admitting that this may be an exceptional rate of increase, it is nevertheless evident upon all sides that the rock drill is going to be a factor of rapidly growing importance in the mines of the Rand. As might be expected, every endeavor is being made to achieve and break records, not only at the development faces but on the stopes. Scarcely a month passes but a new record is announced, and so far in development work the 3¼ inch Ingersoll-Sergeant rock drills have been putting up a speed at this kind of work, which is solidly supporting the excellent reputation which the company long since attained in this department of mining. To take some instances that have come to hand within the last nine months, say,

Given Ratio.	Recip. Ratio.	H	Recip.	J	Recip.	K	Recip.	L	Recip.	M	Recip.	N	Recip.
0.01	100	0.0561	17.825	0.0308	32.467	0.0500	20.000	0.0465	21.505	0.0210	47.619	0.0404	24.752
0.02	50	0.0982	10.018	0.0591	16.920	0.0894	11.185	0.0798	12.531	0.0399	25.313	0.0708	14.124
0.03	33.33	0.1352	7.395	0.0860	11.628	0.1245	8.032	0.1085	9.217	0.0577	17.330	0.0974	10.266
0.04	25.00	0.1688	5.924	0.1171	8.952	0.1566	6.385	0.1341	7.457	0.0747	13.387	0.1215	8.230
0.05	20.00	0.1998	5.005	0.1365	7.326	0.1866	5.359	0.1577	6.334	0.0910	10.989	0.1438	6.954
0.06	16.667	0.2288	4.371	0.1604	6.234	0.2148	4.655	0.1796	5.567	0.1068	9.363	0.1647	6.071
0.07	14.286	0.2562	3.903	0.1836	5.446	0.2415	4.140	0.2002	4.995	0.1222	8.183	0.1844	5.423
0.08	12.50	0.2821	3.544	0.2061	4.852	0.2669	3.746	0.2196	4.553	0.1371	7.294	0.2032	4.921
0.09	11.111	0.3067	3.260	0.2280	4.386	0.2912	3.434	0.2382	4.198	0.1517	6.592	0.2211	4.522
0.10	10.00	0.3303	3.027	0.2493	4.011	0.3145	3.179	0.2558	3.909	0.1659	6.027	0.2383	4.280
0.11	9.09	0.3528	2.834	0.2701	3.702	0.3368	2.969	0.2728	3.665	0.1798	5.561	0.2548	3.924
0.12	8.333	0.3744	2.679	0.2903	3.444	0.3583	2.791	0.2891	3.459	0.1935	5.167	0.2708	3.692
0.13	7.692	0.3952	2.533	0.3100	3.258	0.3790	2.638	0.3049	3.279	0.2069	4.833	0.2862	3.494
0.14	7.143	0.4153	2.407	0.3293	3.036	0.3990	2.506	0.3201	3.124	0.2201	4.543	0.3012	3.320
0.15	6.667	0.4346	2.301	0.3481	2.872	0.4183	2.390	0.3348	2.986	0.2331	4.290	0.3157	3.167
0.16	6.25	0.4532	2.206	0.3665	2.728	0.4370	2.288	0.3491	2.864	0.2458	4.068	0.3298	3.032
0.17	5.882	0.4712	2.122	0.3845	2.601	0.4552	2.197	0.3629	2.755	0.2584	3.870	0.3436	2.910
0.18	5.556	0.4887	2.046	0.4020	2.487	0.4727	2.115	0.3764	2.656	0.2708	3.692	0.3570	2.801
0.19	5.263	0.5055	1.978	0.4192	2.385	0.4897	2.042	0.3896	2.567	0.2830	3.533	0.3700	2.702
0.20	5.00	0.5219	1.904	0.4360	2.293	0.5062	1.975	0.4024	2.485	0.2950	3.390	0.3828	2.612
0.21	4.762	0.5377	1.859	0.4524	2.210	0.5223	1.914	0.4149	2.410	0.3069	3.258	0.3953	2.529
0.22	4.545	0.5531	1.808	0.4685	2.134	0.5378	1.859	0.4271	2.341	0.3186	3.138	0.4075	2.454
0.23	4.348	0.5680	1.760	0.4842	2.065	0.5530	1.808	0.4390	2.277	0.3302	3.028	0.4194	2.384
0.24	4.167	0.5825	1.716	0.4996	2.001	0.5677	1.761	0.4507	2.209	0.3416	2.927	0.4312	2.319
0.25	4.00	0.5966	1.676	0.5147	1.942	0.5820	1.718	0.4621	2.164	0.3529	2.833	0.4426	2.259
0.26	3.846	0.6102	1.638	0.5295	1.888	0.5959	1.678	0.4733	2.112	0.3641	2.746	0.4539	2.203
0.27	3.704	0.6235	1.604	0.5439	1.838	0.6094	1.641	0.4843	2.066	0.3752	2.665	0.4650	2.150
0.28	3.571	0.6364	1.571	0.5580	1.792	0.6226	1.606	0.4950	2.020	0.3861	2.590	0.4759	2.101
0.29	3.448	0.6490	1.541	0.5718	1.748	0.6355	1.573	0.5056	1.977	0.3970	2.519	0.4866	2.055
0.30	3.333	0.6612	1.512	0.5854	1.708	0.6479	1.543	0.5160	1.938	0.4077	2.453	0.4971	2.011
0.31	3.226	0.6731	1.485	0.5986	1.670	0.6601	1.515	0.5262	1.900	0.4183	2.391	0.5074	1.970
0.32	3.125	0.6846	1.461	0.6116	1.635	0.6719	1.488	0.5362	1.865	0.4288	2.332	0.5176	1.932
0.33	3.03	0.6959	1.437	0.6243	1.602	0.6835	1.463	0.5461	1.831	0.4393	2.276	0.5276	1.895
0.34	2.941	0.7068	1.414	0.6367	1.570	0.6947	1.439	0.5558	1.799	0.4496	2.224	0.5374	1.861
0.35	2.857	0.7174	1.394	0.6489	1.541	0.7056	1.417	0.5653	1.768	0.4598	2.177	0.5471	1.827
0.36	2.778	0.7278	1.374	0.6608	1.513	0.7163	1.396	0.5747	1.757	0.4700	2.127	0.5567	1.796
0.37	2.703	0.7379	1.355	0.6724	1.487	0.7267	1.376	0.5839	1.712	0.4800	2.083	0.5662	1.766
0.38	2.632	0.7477	1.337	0.6838	1.462	0.7368	1.357	0.5930	1.686	0.4900	2.040	0.5755	1.737
0.39	2.564	0.7572	1.321	0.6949	1.439	0.7466	1.339	0.6020	1.661	0.4999	2.000	0.5846	1.710
0.40	2.50	0.7665	1.304	0.7058	1.416	0.7562	1.322	0.6109	1.636	0.5097	1.961	0.5937	1.684
0.41	2.439	0.7756	1.289	0.7165	1.395	0.7656	1.306	0.6196	1.613	0.5194	1.925	0.6026	1.659
0.42	2.381	0.7844	1.274	0.7269	1.375	0.7747	1.291	0.6282	1.592	0.5291	1.890	0.6115	1.633
0.43	2.326	0.7929	1.261	0.7370	1.356	0.7835	1.276	0.6367	1.570	0.5386	1.856	0.6202	1.612
0.44	2.273	0.8012	1.248	0.7470	1.338	0.7921	1.262	0.6451	1.550	0.5481	1.824	0.6288	1.590
0.45	2.222	0.8093	1.235	0.7567	1.321	0.8005	1.249	0.6533	1.580	0.5576	1.793	0.6373	1.569
0.46	2.174	0.9172	1.223	0.7662	1.305	0.8087	1.236	0.6615	1.510	0.5670	1.763	0.6457	1.548
0.47	2.128	0.8249	1.212	0.7754	1.289	0.8166	1.224	0.6696	1.493	0.5762	1.735	0.6540	1.529
0.48	2.083	0.8323	1.201	0.7845	1.274	0.8244	1.213	0.6775	1.476	0.5855	1.708	0.6622	1.510
0.49	2.041	0.8395	1.191	0.7933	1.265	0.8319	1.202	0.6854	1.459	0.5947	1.681	0.6703	1.492
0.50	2.00	0.8466	1.181	0.8019	1.247	0.8392	1.191	0.6932	1.442	0.6038	1.656	0.6784	1.474

TABLE OF MEAN EFFECTIVE PRESSURE RATIOS IN THE ADIABATIC

it may be mentioned that at the Van Dyk Mine in November of last year two 3¼ in. Ingersoll drills drove 323 feet in 62 shifts of 9½ hours each. This work was performed at the No. 1 shaft, 5th level east, by two miners named Karlson and Kerr. One white man and five natives worked each shift using two Ingersoll Sergeant drills. At the New Modderfontein G.M. Company, on the 7th level of No. 12 shaft, Messrs. Corris and McHenry, with two 3¼ in. Ingersoll-Sergeant drills, drove during May 267 feet, June 264 feet, and July 295 feet, a total of 826 feet for 156 consecutive shifts. This was a record for consecutive working. At the same mine, in a 11 feet by 8 feet cross-cut, on the 8th level, Mr. Langridge, with two 3¼ inch Ingersoll-Sergeant drills drove 270 feet in 49 single shifts.—*South African Mining Journal.*

MEAN EFFECTIVE PRESSURES IN AIR COMPRESSION OR EXPANSION

By Frank Richards.

The accompanying table and diagram; in connection with those previously given (page 5427), offer special facilities for power computations in connection with the compression or the working expansion of air. The former dealt with the inter-dependent ratios of pressure, volume and temperature, either of which being given, the others were readily derivable therefrom.

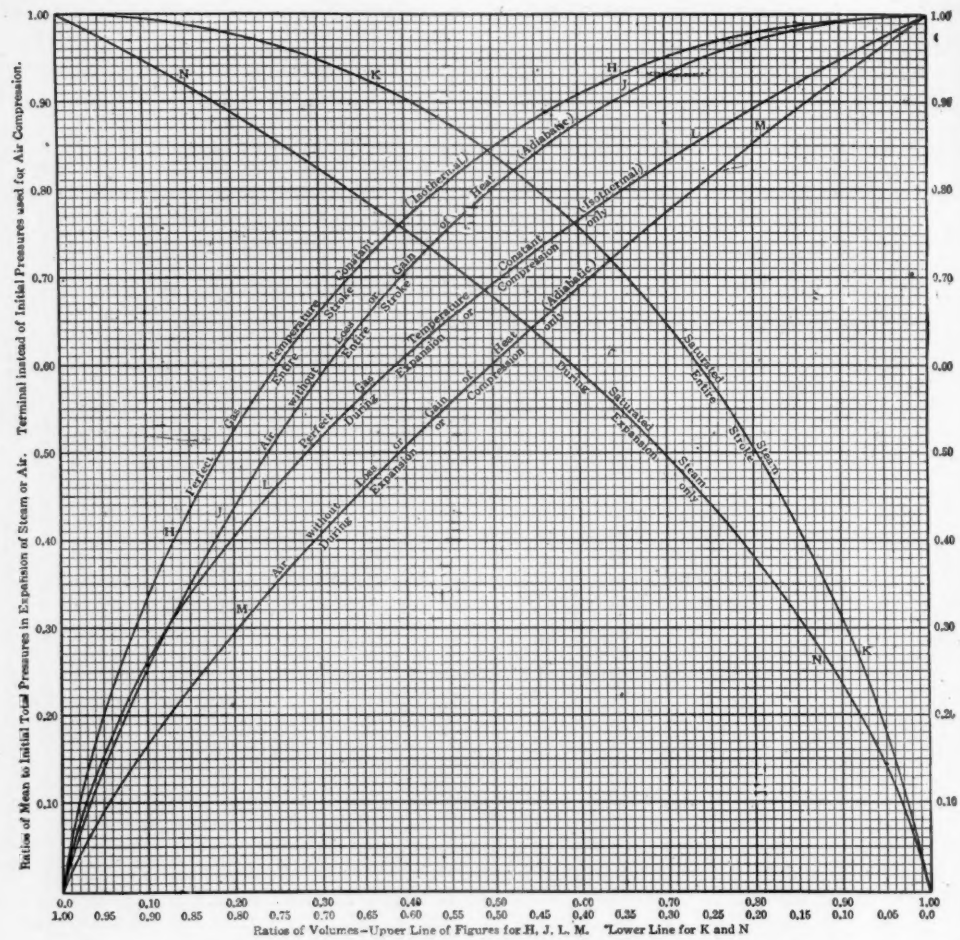
In the table and diagram here presented the given ratio is that of the volumes at the beginning and the end of the stroke. From that is readily determined the mean effective pressure ratio, either during the entire stroke or during compression or expansion only. On

Given Ratio.	Recip. Ratio.	H	Recip.	J	Recip.	K	Recip.	L	Recip.	M	Recip.	N	Recip.
0.51	1.961	0.8534	1.171	0.8103	1.234	0.8463	1.181	0.7008	1.426	0.6128	1.631	0.6863	1.457
0.52	1.923	0.8600	1.163	0.8185	1.222	0.8532	1.172	0.7084	1.410	0.6218	1.608	0.6941	1.441
0.53	1.887	0.8665	1.154	0.8264	1.210	0.8599	1.162	0.7159	1.396	0.6307	1.585	0.7019	1.424
0.54	1.852	0.8727	1.147	0.8342	1.191	0.8664	1.154	0.7234	1.382	0.6396	1.563	0.7096	1.409
0.55	1.818	0.8788	1.137	0.8418	1.188	0.8727	1.145	0.7307	1.368	0.6484	1.542	0.7172	1.394
0.56	1.786	0.8847	1.130	0.8492	1.177	0.8789	1.137	0.7380	1.355	0.6572	1.521	0.7247	1.379
0.57	1.754	0.8904	1.123	0.8563	1.167	0.8848	1.130	0.7451	1.342	0.6659	1.501	0.7322	1.365
0.58	1.724	0.8959	1.116	0.8633	1.158	0.8906	1.122	0.7522	1.329	0.6745	1.482	0.7396	1.352
0.59	1.695	0.9013	1.109	0.8701	1.149	0.8962	1.115	0.7593	1.317	0.6831	1.463	0.7469	1.338
0.60	1.667	0.9065	1.103	0.8767	1.140	0.9017	1.109	0.7662	1.305	0.6917	1.445	0.7541	1.326
0.61	1.639	0.9115	1.097	0.8831	1.130	0.9069	1.102	0.7731	1.293	0.7002	1.428	0.7613	1.313
0.62	1.613	0.9164	1.091	0.8893	1.124	0.9120	1.096	0.7800	1.282	0.7086	1.411	0.7684	1.301
0.63	1.587	0.9211	1.085	0.8953	1.116	0.9169	1.090	0.7867	1.271	0.7170	1.394	0.7755	1.289
0.64	1.563	0.9256	1.080	0.9011	1.109	0.9217	1.085	0.7934	1.259	0.7254	1.378	0.7824	1.278
0.65	1.538	0.9300	1.075	0.9068	1.102	0.9263	1.079	0.8000	1.250	0.7337	1.362	0.7894	1.266
0.66	1.515	0.9342	1.070	0.9123	1.096	0.9307	1.074	0.8066	1.239	0.7419	1.347	0.7962	1.256
0.67	1.493	0.9383	1.065	0.9176	1.089	0.9350	1.069	0.8131	1.229	0.7501	1.333	0.8030	1.245
0.68	1.471	0.9423	1.061	0.9227	1.083	0.9391	1.064	0.8196	1.220	0.7583	1.320	0.8097	1.235
0.69	1.449	0.9460	1.057	0.9276	1.078	0.9431	1.060	0.8259	1.210	0.7664	1.304	0.8164	0.224
0.70	1.429	0.9497	1.053	0.9324	1.072	0.9469	1.056	0.8322	1.201	0.7745	1.291	0.8230	1.215
0.71	1.408	0.9532	1.049	0.9369	1.067	0.9506	1.052	0.8385	1.192	0.7826	1.277	0.8296	1.205
0.72	1.389	0.9565	1.045	0.9414	1.062	0.9541	1.048	0.8447	1.183	0.7906	1.261	0.8361	1.196
0.73	1.370	0.9597	1.042	0.9456	1.057	0.9575	1.044	0.8509	1.175	0.7885	1.252	0.8426	1 186
0.74	1.357	0.9628	1.038	0.9497	1.053	0.9607	1.040	0.8570	1.166	0.8064	1.240	0.8490	1 177
0.75	1.333	0.9658	1.035	0.9536	1.048	0.9638	1.037	0.8631	1.158	0.8143	1.228	0.8553	1.169
0.76	1.316	0.9686	1.032	0.9573	1.044	0.9668	1.034	0.8691	1.150	0.8221	1.216	0.8616	1.161
0.77	1.299	0.9713	1.029	0.9609	1.040	0.9696	1.030	0.8750	1.142	0.8300	1.204	0.8679	1.152
0.78	1.282	0.9738	1.026	0.9643	1.036	0.9723	1.028	0.8809	1.135	0.8377	1.193	0.8741	1.144
0.79	1.266	0.9762	1.024	0.9675	1.033	0.9749	1.025	0.8868	1.127	0.8455	1.182	0.8803	1.136
0.80	1.25	0.9785	1.022	0.9706	1.030	0.9773	1.023	0.8926	1.120	0.8532	1.172	0.8864	1.128
0.81	1.235	0.9807	1.020	0.9736	1.027	0.9796	1.021	0.8983	1.113	0.8608	1.161	0.8925	1.120
0.82	1.22	0.9827	1.017	0.9763	1.024	0.9817	1.018	0.9041	1.106	0.8684	1.151	0.8985	1.113
0.83	1.205	0.9847	1.015	0.9789	1.021	0.9838	1.016	0.9097	1.099	0.8760	1.141	0.9045	1.105
0.84	1.19	0.9865	1.013	0.9814	1.019	0.9857	1.014	0.9154	1.092	0.8836	1.129	0.9104	1.098
0.85	1.176	0.9881	1.012	0.9837	1.016	0.9874	1.012	0.9209	1.085	0.8911	1.122	0.9162	1.091
0.86	1.163	0.9897	1.0104	0.9858	1.014	0.9891	1.010	0.9265	1.079	0.8986	1.112	0.9221	1.084
0.87	1.149	0.9912	1.0089	0.9878	1.012	0.9906	1.009	0.9320	1.072	0.9060	1.103	0.9279	1.077
0.88	1.136	0.9925	1.0075	0.9896	1.010	0.9920	1.008	0.9375	1.066	0.9134	1.094	0.9337	1.071
0.89	1.124	0.9937	1.0061	0.9913	1.0087	0.9933	1.0067	0.9429	1.060	0.9208	1.086	0.9394	1.063
0.90	1.111	0.9948	1.0052	0.9928	1.0072	0.9945	1.0055	0.9482	1.054	0.9282	1.077	0.9451	1.058
0.91	1.099	0.9958	1.0042	0.9942	1.0058	0.9956	1.0044	0.9536	1.048	0.9355	1.069	0.9508	1.051
0.92	1.087	0.9967	1.0033	0.9954	1.0046	0.9965	1.0035	0.9589	1.042	0.9428	1.060	0.9564	1.044
0.93	1.075	0.9975	1.0025	0.9965	1.0035	0.9973	1.0027	0.9642	1 037	0.9500	1.052	0.9620	1.039
0.94	1.064	0.9982	1.0018	0.9974	1.0026	0.9981	1.0019	0.9694	1.031	0.9572	1.044	0.9675	1.033
0.95	1.053	0.9987	1.0013	0.9982	1.0018	0.9987	1.0013	0.9746	1.026	0.9645	1.036	0.9730	1.0277
0.96	1.042	0.9992	1.0008	0.9989	1.0011	0.9991	1.0009	0.9797	1.0207	0.9716	1.029	0.9785	1.0219
0.97	1.031	0.9996	1.0004	0.9994	1.0006	0.9995	1.0005	0.9849	1.0155	0.9788	1.021	0.9840	1.0162
0.98	1.02	0.9998	1.0002	0.9997	1.0003	0.9998	1.0002	0.9899	1.0102	0.9859	1.014	0.9895	1.0106
0.99	1.01	0.9999	1.0001	0.9999	1.0001	0.9999	1.0001	0.9950	1.005	0.9929	1.007	0.9947	1.0053
1.00	1.00	1.00	1.00	1.00	1.00	1 00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

COMPRESSION OR EXPANSION OF AIR.

the diagram, the given ratio of volumes is read upon the base line and the required ratio of the mean effective pressure is then indicated by the vertical height from the point thus indicated up to the curve representing the required data. It is assumed that no further explanation is required.

In computations relating to the power developed in the working expansion of air in a reciprocating engine or motor, the ratio of volumes is the particular most readily available, as that is determined by the point of cut-off, but in air compression we first know the ratio of pressures, and the ratio of volumes is derivable from this by the assistance of the previous table or diagram, so that both tables or diagrams are necessary to constitute a complete equipment, and they should be kept together. Of course only absolute pressures are dealt with, and when mean effective pressures are obtained, these also are absolute, and the actual working mean effective is obtained by deducting the pressure of the atmosphere. In compound compression or expansion, there must be subtracted the total absolute back pressure, which of course must be much greater than that of the atmosphere alone.



RATIOS OF MEAN EFFECTIVE PRESSURES IN ADIABATIC COMPRESSION

The several columns of the table designated by capital letters, and the corresponding lines of the diagram, represent the following ratios of mean to initial, or terminal, total pressures, the given ratio in each case being the ratio of volumes.

FOR ENTIRE STROKE.

H, Perfect gas, temperature constant.

J, Air expanding (or being compressed) without loss or gain of heat.

K, Saturated steam.

DURING EXPANSION OR COMPRESSION ONLY.

L, Perfect gas, temperature constant.

M, Air expanding (or being compressed) without loss or gain of heat.

N, Saturated steam.

The following are the formulas by which the computations were made, $\frac{1}{R}$ being the given ratio:

$$H \ldots\ldots\ldots \frac{1 + \textit{hyp. log. } R}{R}$$

$$J \ldots \frac{3.451 - 2.451 + \left(\frac{1}{R}\right)^{0.408}}{R}$$

$$K \ldots\ldots 17 \times \frac{1}{R} - 16 \times \left(\frac{1}{R}\right)^{\frac{17}{16}}$$

$$L \ldots\ldots\ldots\ldots \frac{\textit{hyp. log. } R}{R - 1}$$

$$M \ldots \frac{2.451 \times \left[1 - \left(\frac{1}{R}\right)^{0.408}\right]}{R - 1}$$

$$N \ldots\ldots \frac{16 \times \left[1 - \left(\frac{1}{R}\right)^{\frac{1}{16}}\right]}{R - 1}$$

Habits of computation vary with the individual, some paying more attention to minute points than others, and some doing mentally what would compel a liberal use of pencil and paper by others. In any case the detailed descriptions of arithmetical operations are apt to make them appear more complicated than they really are.

We will take here a very simple case of single-stage compression. Say that we have a straight-line compressor whose air cylinder is 24-inch diameter and 36-inch stroke, piston rod 4 inches, running at 72 revolutions per minute and compressing the air to 7 lb., gage; what will be the theoretic horsepower required for adiabatic compression? The area of a 24-inch circle is 452.39 square inches, and of a 4-inch is 12.56. Then (452.39 + 452.39 — 12.56) ÷ 2 = 446 square inches, as the mean piston area for both strokes.

As the compression is to 70 pounds, gage, the absolute pressure is 70 +14.7 = 84.7, and the pressure ratio is 14.7 ÷ 84.7 = 0.1736. Referring to the table in the previous article to get the ratio of volumes (page 5428) using column *A*, we find that for 0.17, or 0.1700, it is 0.2841, and for 0.1800 it is 0.2959, the difference being 0.2959 — 0.2841 = 0.0118, then 0.0118 × 0.36 = 0.004248, and 0.2841 + 0.0042 = 0.2883 as the ratio of volumes.

Coming now to the table before us, using column *J*, we find that for 0.2800 volume ratio, the mean effective pressure ratio is 0.5580 and for 0.2900 it is 0.5718, the difference being 0.0138, then 0.0138 × 0.83 = 0.0114 and 0.5580 ÷ 0.0114 = 0.5694 as the mean effective pressure ratio.

It is usually not necessary, or, indeed worth while, to take all this pains to get the last two figures of the ratio, and in using the diagrams alone the operation would be much simpler. The pressure ratio, 0.1736, we would fix in our minds at 0.17⅓+, and finding this point on the base line of the previous diagram we would read the vertical distance up to curve *A* as 0.28⅞—. Then turning to the diagram now before us, with 0.28⅞ — on the base line, we would read the vertical distance to curve *J* as 0.57, which would be sufficiently close to the 0.5694 obtained from the table.

The absolute terminal pressure of compression being 84.7, the absolute mean effective pressure is 84.7 × 0.5694 = 48.23, and the working mean effective is 48.23 — 14.7 = 33.5.

The theoretic horsepower then is: 446, mean piston area × 33.5 mean effective resistance × 6 ft. per double stroke × 72 revolutions per minute, ÷ 33,000 foot pounds = 196 horsepower, to which is to be added for friction whatever percentage information may warrant or judgment suggest.—*American Machinist.*

SOME AIR LIFT DATA

By G. A. Reichard.

Air lifts are used to quite an extent in this section, Los Angeles, Cal., for raising water and oil, in some cases operating in oil wells 2000 feet deep or more. In many cases the cost of installation is moderate and in all cases the cost of maintenance is very low, and air lifts, with compressors of any reasonable size, can be operated more economically than ordinary deep-well pumps. There are many situ-

tions where they are really the most economical appliances that can be used.

It is necessary, however, to have a proper amount of submergence to get economical operation. The exact amount of submergence for best work varies a little with the lift and quantity of water handled. Ordinarily, for lifts of 40 feet or less I would recommend about 2½ to 1, that is, 2½ times the amount of pipe below the surface of the water in the well when pumping the maximum quantity, to the lift above this level. With lifts of from 50 to 80 feet, 2 to 1 generally gives good results. On deeper lifts 1½ to 1 is frequently used. There are situations where sufficient submergence cannot possibly be obtained, and while the pumps may be operated with considerably less submergence, it generally increases the cost of pumping somewhat.

The quantity of air required depends somewhat on the size of the installation, the proper proportioning of the pipes, flow of water in the wells, etc., and it is impossible to give the exact quantity, as it is very seldom that two wells will work exactly alike.

I give herewith a table showing the approximate quantity of air required and working pressure for all ordinary cases. but know of a number of installations that are operated successfully with from 15 to 20 per cent. less air than is shown in this table, and a few installations that use more.

In selecting a compressor it is well to allow a surplus over the amount given in the table, as it cannot always be known before testing how much the water in the wells will fall when being pumped; and while some of the better makes of the larger sizes of compressors will give a volumetric efficiency of over 90 per cent., there are some of the smaller sizes of compressors, with poppet-inlet valves, that are deficient in inlet-valve area, and some of them will not deliver 60 per cent. of the amount of air that is shown by piston displacement when running at full speed. This, of course, varies with the inlet-valve area and speed.

The size of air pipe is not very important, providing it is large enough to carry the air without undue friction, and the working pressure given is based on there being very little friction.

The size of the pipe in which the water is lifted to the surface is, however, quite important, as there must be a fairly high velocity to work properly, and it is better to err in having the pipe a little too small than too large. The best work is generally obtained with a flow of from 12 to 18 gallons per minute per square inch of section. Smaller pipes will not stand quite so high a velocity as larger sizes.

The arrangement of the air nozzles at the bottom is not a matter of very great importance, provided, of course, the air pipe is somewhat above the bottom of the water pipe. There are a number of different arrangements that give good results.

In some cases, where it is desired to deliver the water at some distance away from and above the well, where sufficient submergence cannot be obtained, air-displacement pumps are used, that is, a cylinder or chamber is lowered into the well below the water line and

APPROXIMATE CUBIC FEET OF FREE AIR AND WORKING PRESSURE REQUIRED TO RAISE ONE GALLON OF WATER BY "AIR LIFT."

	Ratio of Submergence to Lift.							
	1 to 1.		1½ to 1.		2 to 1.		2½ to 1	
Lift in Feet.	Free Air. Cubic Feet.	Working Pressure, Pounds.	Free Air, Cubic Feet.	Working Pressure, Pounds.	Free Air, Cubic Feet.	Working Pressure, Pounds.	Free Air, Cubic Feet.	Working Pressure, Pounds.
20	0.428	9	0.31	13½	0.252	18	0.217	22½
30	0.47	13½	0.35	20	0.29	27	0.255	34
40	0.508	18	0.387	27	0.325	36	0.287	45
50	0.546	22½	0.422	34	0.36	45	0.32	56
60	0.582	27	0.457	40½	0.392	54	0.35	67½
80	0.653	36	0.522	54	0.455	72	0.41	90
100	0.72	45	0.585	67½	0.512	90	0.465	112½
120	0.785	54	0.642	81	0.567	108	0.52	135
140	0.847	63	0.697	94½	0.622	126	0.572	157½
160	0.907	72	0.755	108	0.675	144	0.624	180
180	0.965	81	0.81	121½	0.725	162	0.672	202
200	1.022	90	0.862	135	0.775	180	0 72	225

provided with valves somewhat similar to pump cylinders, being alternatively filled and emptied with air under pressure. What is known as the "dense air" system, by which the air is returned to the compressor under considerable pressure, increases the economy of the compressor and makes a satisfactory and very economically operated pumping plant.

Direct-acting deep-well steam pumps are generally very wasteful in the use of steam and very seldom are any more economical to operate than a good air-lift system, properly installed. All kinds of deep-well pumps, having a long line of rods, generally, are quite expensive to maintain, to say nothing of the trouble and time lost in pulling and replacing rods and buckets. They are good things to keep away from wherever it is possible, particularly where any considerable quantity of water is required from deep wells. However, when operated at very slow speeds and large capacity is not required, their use is sometimes admissible.—*Power and the Engineer.*

PURIFYING WATER BY OZONE

Ozone is the best agent for purifying water, because it adds nothing except oxygen, which assists in aeration. An ozonizing plant has recently been installed at Saint Maur, near Paris, where the water of the Marne River was found to contain many disease germs, even after it had passed through sedimentation basins and sand filters. The ozone generators are of the Siemens type and are operated by a high-tension alternating circuit obtained by transforming the current of a 110-volt alternator, which is driven by a 44-horse-power steam engine. The total consumption of energy is 1 kilowatt hour for each 1,200 cubic feet of water, and more than half of the energy is employed in working the compressing pumps. The cost of sterilization is less than 5 cents per thousand cubic feet. The temperature of the water is lowered by the operation, and not a trace of nitrous oxide, chlorine compounds, hydrogen dioxide, or metallic salts due to corrosion of the apparatus can be detected in the sterilized water. Of the ozone absorbed, 73 per cent is consumed immediately in sterilization, 7 per cent. remains diffused through the water and exerts a subsequent sterilizing effect, and 20 per cent. escapes into the atmosphere.—*Scientific American.*

PNEUMATIC JAM RIVETER MECHANISMS

The operation of hot riveting in boiler-making and bridge work requires a final squeeze of great intensity, and for this service the hydraulic riveter would seem to be specially adapted since its ordinary working pressures are 1000 to 1500 pounds per square inch and upward, which pressures are inpracticable for compressed air in such lines of work. The objections to the use of the hydraulic riveter, however, the weight of the machine, its unportability, its slowness in action, have suggested opportunities to inventors to supersede it, and now air at ordinary working pressures, not exceeding 100 pounds to the square inch, is ready to do any kind of work which has ever been done by the hydraulic riveter and without its objectionable accompaniments. Mr. W. T. Sears, in a recent issue of the *American Machinist,* discusses the devices which have secured the success of the pneumatic riveter.

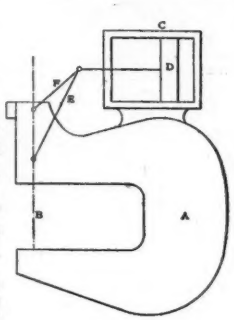


FIG. 1.

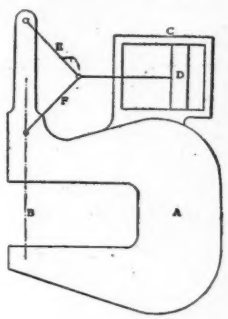


FIG. 2.

The most familiar designs of pneumatic riveters are the so called toggle machines. These are commonly of two types, Fig. 1 and Fig. 2. *A* is the riveter frame, *B* the center line of dies, *C* the cylinder, *D* the piston, *E* the toggle link connected to the frame, and *F* the toggle link connected to the plunger which carries the movable riveting die. In both of these machines, the toggles straighten out or, in other words, reach a point where the pressure exerted or leverage obtained theoretically runs up to infinity.

Such extreme pressures are of course not actually reached or even approximated, owing to the spring of the different parts, and of the riveter frame especially. This is shown graphically in Fig. 3, in which the curve *AA* represents the theoretical pressure curve exerted by

a toggle at different points of piston travel, horizontal distance representing piston travel and vertical distance pressure exerted. Assuming the die first strikes the rivet at point *D*, then the pressure on the rivet would be somewhat along the curve *BB*. These curves are not actually figured, but are near enough for practical purposes of illustration.

The curve *BB* must of course keep below the curve *AA*, otherwise the riveter would stall. In actual practice this stalling often takes place say, at some place on curve *AA*, as at *Y*, when the riveter must be reversed, and the plunger length shortened by turning the screw die holder. At the next stroke the anvil will be

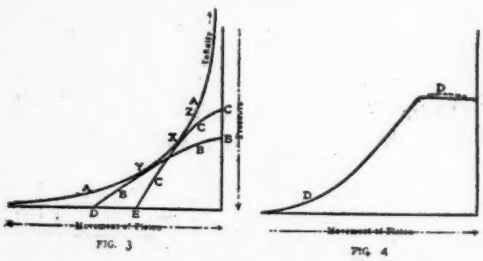


FIG. 3

FIG. 4

struck later as at *E*, and the pressure curve will run up on some such line as *CC*.

If the die has been shortened sufficiently, the stroke will be completed and the critical point (in this case *X*) passed. From here on the pressure that can be exerted at the dies increases much faster than the resistance or, as shown in the diagram, the curve *AA* rapidly leaves *CC*, and the result is that the piston jumps with a quick movement to the end of its stroke, and the toggle hits its stop with a sharp rap. One of the chief losses in air is due in riveters of this class to the additional strokes taken, for unless there is the same amount of material in the rivet to be upset each time, and the riveted parts of almost exactly the same thickness, the die length must be adjusted often, and it is seldom or never adjusted correctly on the first stroke.

By repeating the strokes and adjusting the die length a little at each stroke, the point *X* can be carried higher and higher on the pressure line *AA* with the result, that the final riveting pressure, or *C'*, is somewhat increased over that obtained on the first stroke, or *B'*. This pressure is always indefinite, although by taking a number of strokes on each rivet the variation is much reduced, and the maximum approximated. Of course the curves *BB* and *CC* are not accurate; they vary with the size of the riveters, the length of the rivet, the thickness of material riveted, and the temperature of rivets themselves. The general action is, however, clearly shown, which is that the resistance at first is considerably less than the pressure which can be exerted; that these two quantities approach nearer and nearer (provided we assume the riveter is to exert its maximum pressure) until the variable critical point is reached. Beyond this point the pressure which the machine can exert rapidly increases over the resistance and the machine goes over with a bang, unless it is cushioned in some manner. The final pressure in most cases, is not much more than the pressure at the so-called critical point.

This indefiniteness of pressure is one of the main reasons for retarding a more general use of pneumatic riveters, and has prevented their superseding the hydraulic riveter to the great extent they undoubtedly would have done if this weakness had not existed.

While the action has been known and appreciated for many years, it is only comparatively lately that any good mechanical attempts have been made to modify the simple toggle riveter so that a known maximum riveting pressure can be exerted through some considerable distance. The problem has been attacked in several ways, the attempt being to approximate a curve similar to full line *DD*, Fig. 4, and up to date the writer is acquainted with three or four which give or approach this result more or less closely. In any event they come nearer to it than types shown in Figs. 1 and 2.

There are one or two others of such design that they are or could be so arranged as to give this ideal pressure curve, but owing to the manner in which the reduction of motion is obtained, the details of the parts that take thrust cannot be made so as to give satisfactory service at a reasonable cost of manufacture for pressures now demanded for riveting.

Fig. 5 shows one of these machines in which the pressure it is capable of exerting follows very closely along the line *DD* in Fig. 4.

The first action is somewhat similar to the toggle movement illustrated in Fig. 2, and the flattening of the curve at the end of the stroke

is due to the movement of the link *G* around the end of link *E*. *F* is the compression link. It is connected to link *G* on one end, and to the plunger that carries the die on the other. *H* is simply the guide link for the system and forces it to move in the desired manner. If there is any serious criticism to be made of this toggle machine, it would probably be as regards the considerable number of levers or links which are used.

Fig. 6 shows a modification of Fig. 1. In this case the links *E* and *G* act as a single link until they reach approximately the position

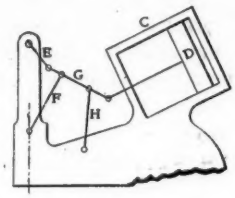


FIG. 5

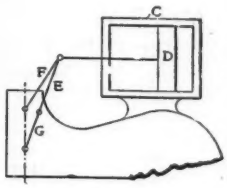


FIG. 6

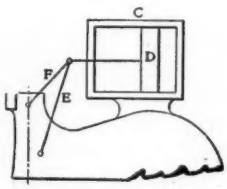


FIG. 7

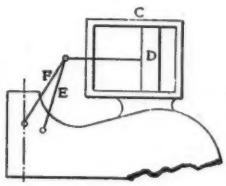


FIG. 8

shown in the sketch. At this point, link *G* is stopped, and the links *E* and *F* complete the movement. As they are about the same length, the action while the lower end of link *F* is passing by the lower end of link *E*, gives a very nearly constant pressure for some little distance at the end of the stroke. This is considerably simpler than Fig. 5, and the pressure curve is practically the same; but the use of a jointed link in the manner shown, requires an additional spring or cylinder to control the movement of the link *G*.

Fig. 7 shows a modification which is but very little different from Fig. 1, except that the lower end of link *E* is moved back from the center line of the plunger that carries the die, with the result that the pressure curve does not rise at the end to quite the extent that it does on the type shown in Fig. 1. This curve, referred to before as *AA* in Fig. 3, is somewhat shortened, and the pressure would perhaps stop increasing at some point such as *Z*.

The general outline of the curve would not differ much from that given by Fig. 1. It is somewhat better, however, in that the surplus end pressure has been cut off, but if the stroke were to be continued until the center lines of links *E* and *F* coincide, the same conditions regarding infinity would occur. There is really no very appreciable flattening of the pressure curve at the end of the stroke, which is desirable.

Fig. 8 illustrates an arrangement of links which is very simple. There are no more parts than are used in Fig. 1 and 2, but the pressure curve closely approximates the line *DD* in Fig. 4, the variations being shown by the dotted line. In this device, the theoretical pressure can never reach infinity, for there is no possibility of the links *E* and *F* ever coming into the same line, unless moved through a half revolution, which is far beyond the limit of the stroke of machine. The actual curve follows very closely the one given by the machine shown in Fig. 6.

With a machine which is capable of giving a pressure curve approximately like *DD* in Fig. 4, the one uncertainty of the riveting pressure exerted by a pneumatic riveter disappears, and also the bother of continually adjusting the die length for slight variations in thickness, and other inequalities of the work.

It is simply necessary to be sure that the point of maximum pressure has been reached, and this can easily and surely be ascertained, by means of a signal such as the escape of air or by noting the position of some part of the link system. There is therefore no reason why such riveters should not take the place of, and satisfactorily perform the duty of any hydraulic riveter, especially for moderate pressure of, say, up to 75 or 80 tons, and that this is so is proved by the experience of such machines in many shops.

Compressed air in shops is coming to be more and more recognized as a necessity, and the list of operations on which a great saving can be made is increasing rapidly, and for this reason the above article was written. It calls attention to some points regarding riveting by air that are not generally recognized by shop men at large.

DETAILS OF THE BLASTING OPERATION

When the miner has completed the holes he is ready to blast. The powder used is sold in boxes which contain a certain number of sticks of powder of the shape and size of an ordinary candle, with both ends flat. There are usually thirty sticks in a ten-pound box, and as dynamite freezes at forty degrees temperature the sticks are more or less stiff. The powder is contained in strong, yellow paper, and the miner cuts it with his knife to give the stick a better chance to pack. The stick of powder is pushed into the hole and is packed carefully with a long wooden stick. The powder is introduced cut in several pieces, and the cap and the fuse are introduced with the last piece. The fuse is a cord of guttapercha containing in its ecnter a column of fine gunpowder.

The miner lights the fuse and goes to some place of safety. During this time the black powder burns inside the fuse, reaches the cap, explodes it and with it the giant powder, which is transformed into gases. The gases expand so as to occupy a space twenty thousand times greater than the one in which they are enclosed. They thus develop a pressure of more than thirty tons per square inch and force the solid rock to break into fragments to give them room to escape. The rocks are streaked by numerous slips, planes of fracture or lines of least resistance, along which the rock breaks in a few big chunks, or "breaks big," as the miners say; or it breaks into a thousand small pieces.

In every day practice a miner seldom drills and fires a single hole at a time. He drills in the breast or in the face of the workings several holes of various lengths and inclined at different angles. He disposes them in such an order and at such places that each explosion will work to the best advantage. The first hole not only will take a part of the block to be broken but it will loosen a side of the piece of rock to be blasted by the second hole, and help the powder in this hole to accomplish its work. The second hole will make easier in the same manner the work of the third one, and so on till the last one has exploded. The holes have to be fired in a carefully arranged order to give their maximum of results. With that end in view the miner cuts the fuses of different lengths, the second two inches longer than the first and the next two inches longer again, till the last, which is the longest of all. A practical hand can light the fuses so quickly that the difference of time in lighting them does not count.

The miner counts the explosions to make sure that all the holes have exploded. He knows then that he can safely pick the ground that he can pry and tear down, without danger, all the pieces of rock which have been shaken by the explosions but which are yet partially held by the solid rock.

In some cases, in the breast of a long and straight tunnel, for instance, the miner would have to walk too far before being out of danger. It has become the practice in such cases to fire all the holes at the same time from a distant and safe place by means of an electric battery.—*Mining Science.*

HAMMER DRILLS FOR SMALL SEWER WORK

The city of Bloomington, Ind., put off as long as possible the building of certain necessary sewers on account of the cost, as it involved much rock cutting. These sewers have now been built, and an account of the operations has been written for *Engineering News* by Mr. Geo. L. Thon. What follows is an abstract of Mr. Thon's paper.

Bloomington is located in the oolitic limestone region. This stone is the Bedford limestone which is quarried extensively in this locality for building purposes. The stone is found close to the surface of the ground, and in many cases outcrops in the surface of the street. Where it is covered with soil, the rock surface is generally very uneven, as was subsequently shown when the trenches were opened. Sometimes there would be a series of "hogbacks" extending across the trench, which were from 2 to 8 ft. wide outcropping or nearly outcropping on the surface, and between these "hogbacks" would be seams of clay extending sometimes even below the grade line of the sewer. The average depth of the sewers was about 6½ ft., except about 1,000 ft., which was laid in a cut or from 9 to 12 ft. The rock excavated from the trenches varied from a few inches to 12 ft. in depth.

The rock excavation being a large item in this contract, the necessity of an economical method of rock excavation was apparent. The contractor's attention was called to the use of

hammer drills for this kind of work, and after obtaining one of these drills and testing its use on work of this kind, and being satisfied with the results obtained, installed two air compressor outfits with six hammer drills for each outfit. One of the air compressors installed was steam driven and the other was belt driven. The belt-driven machine was a 10x12-in. single stage air compressor, rated at 140 cu. ft. of free air per minute at 100 lbs. pressure when operated at a rate of 150 r.p.m. The other was a steam-driven single-stage 8x9x12-in. air compressor and rated at 124 cu. ft. of free air per minute at a pressure of 100 lbs. at 150 r.p.m. Both compressors were driven by a 16-HP. traction engine.

Each compressor outfit included about 1,000 ft. of 1½-in. wrought iron air pipe, 6 hammer rock drills with the necessary steel bits, 7-16-in. air hose, reheaters, valves, etc., with a small 7x9-ft. tool house. The tool house was mounted on a skid so that it could be pulled along the line of the work with the rest of the outfit by means of the traction engine. The belt-driven air compressor was also mounted on a skid, and the steam-driven compressor was mounted on a set of four heavy wagon wheels. The compressors were pulled along the line of the work as it progressed by the traction engines.

The cost of an outfit of this kind was as follows: The air compressors, each including an air drum, 1,000 ft. of 1½-in. pipe with valves, etc., cost about $800 each. The hammer drills cost $55 each. Fifty feet of 7-16-in. air hose for each drill cost $9, and the steel bits, which were of extra quality of steel, cost $2.50 each, for the three-foot lengths and proportionally more or less for the 2 and 4-ft. lengths. The total cost of each drilling outfit was about $1,300. The two traction engines that were used to drive the air compressors were rented at the rate of $5 per day from a local man. This included the cost of an engineer for each engine. The contractor furnished the fuel and oil.

These compressor outfits ran five drills successfully at a distance as high as 1,200 ft. from the air compressor, and by running the air compressor up to 110 lbs. pressure five drills could be operated at a distance of 1500 ft. from the compressor. On account of friction losses and leakage in the main pipe, 1500 ft. was about as far from the compressor as the drills could be economically operated.

The outfit was generally moved at intervals of about 1000 ft. along the line of the work, as it was easier to move the entire outfit than to operate with a longer air line. Moving the compressor outfit was a very simple matter. The pipe was unjointed and placed on a rack on the side of the tool house and then the air compressor and the tool house were chained to the rear of the traction engine and the whole outfit dragged to the next place where it was needed. In drilling close to the air compressor six drills could easily be supplied with sufficient air for drilling, but ordinarily only five drills were used, the extra drill being kept on hand for use in case any of the other drills had to be sent to the shop for repairs.

REHEATING.

During the winter when the temperature was below freezing, heaters were used to reheat the air just before it entered the drill. These heaters were placed in the air line between the main air pipe and the drill. The heaters were made of a ½-in. pipe 16 ft. long, which was bent in the form of a coil so that it could be inserted in the cylinder of an ordinary kerosene oil heater. The air supplying the drill passed through this coil of pipe, which was kept heated by the oil heater. In passing through this heated coil of pipe it became warm and materially increased the efficiency of the drill in cold weather.

Another form of heater used for the same purpose, and which proved even more satisfactory than the kerosene heater, was made by inserting a piece of 3-in. pipe 15 ins. long in the pipe supplying the drill. The 7-16-in. air supply pipe was enlarged by means of a bushing to the size of a 3-in. pipe, and then at the other end of the 3-in. pipe was reduced to the original size of the air supply pipe by the same means. This short enlarged section through which the air supplying the drill must pass at a decreased velocity is kept hot by means of a coal fire in a salamander. These methods of reheating the air proved fairly satisfactory and made it possible to work the drills on the coldest days during the winter.

The drills used are comparatively small, weighing about 20 lbs., and are easily handled by one man, a feature that led largely to their adoption in this work. The bits used in this work were of 2, 3 and 4-ft. lengths. When

more than four feet of rock was excavated from the trench, 4-ft. holes were drilled and blasted and then the rock was redrilled. The bits are made of a hexogonal steel shank 1 in. in diameter, with a 5-16-in. hole running from end to end through the center of the bit. The cutting end of the bit is dressed to 1¼-in. gage and finished with a "rose" or eight winged cutting end. Part of the exhaust air from the drill is discharged through the hole that extends down through the bit to the bottom of hole being drilled, and in this way the hole is kept clean from dust. The drill when the bits are newly sharpened bores a hole 1¼ ins. in diameter, but as the bits wear the size of the hole drilled decreases. When the hole drilled becomes less than one inch in diameter the bits are resharpened.

But one man was required to operate a drill, and almost any ordinary laborer can learn to operate the drill in a few minutes and get good results. In fact, all the drillers on this work were selected from the laborers on the ditch and were men who had never seen a drill of this kind before. The men operating the drills were paid 17½ cts. an hour, which was but 2½ cts. an hour more than the wages paid for ordinary labor.

The cost of operating each drill outfit per day was approximately as follows:

Rent of traction engine, including engineer	$5 00
Five drillers, at 17.5 cts. per hour	8 75
Fuel and oil	3 00
Blacksmithing and new steel	1 00
Foreman	3 50
Water boy	50
Total cost per day	$21 75

With this outfit in a dry trench and fairly uniform rock, 5 drillers drilled 263 holes, each hole 3 ft. deep in a shift of 10 hours, or a total of 789 ft. of hole at a cost of 2.75 cts. per lin. ft. of hole drilled. This is probably about the average cost of drilling under reasonably favorable conditions in a dry trench. In a wet trench where the rock surface was covered with mud and water, the speed of drilling was somewhat retarded. In one case, however, in a trench where the majority of holes were drilled in rock covered with from 2 to 4 ins. of water, one man drilled 40 holes each 3½ ft. deep in seven hours, which is at a rate of 0.33 ft. of hole per minute. In another instance one man drilled 100 holes, each 18 ins. deep, in 10 hours, or at a rate of 0.25 ft. of hole drilled per minute, this being also in a wet trench.

The drillers experienced considerable difficulty in places, due to mud seams, which often underlaid the rock surface. When the bit struck a mud seam it would generally choke up the exhaust hole of the bit. When this happened, the hole drilled in the rock would not be cleaned from dust as it went down and difficulty was then encountered in getting the bit out of the hole when the drilling was finished. In some cases it was necessary to leave the bit in the hole until the rock was broken up by the blast from the adjacent holes.

The accompanying table shows the average rate of drilling holes by means of these drills as used in this work under actual working conditions:

RATE OF DRILLING 1¼-IN. HOLES IN OOLITIC LIMESTONE WITH HAMMER DRILLS. BLOOMINGTON SEWERAGE SYSTEM.

Depth of hole drilled, ins.	Time started.	Time stopped.	Total time per hole, mins.	Depth of hole drilled per minute, ft.
16	11.44 a. m.	11.47 a. m	3.	.45
20	11.44 a. m.	11.47 a. m.	3.	.55
18	11.48.5a. m.	11.51 a. m.	2.5	.60
22	11.51.5a. m.	11.54 a. m.	2.5	.73
18	11.51 a. m.	11.54 a. m.	3.	.50
24	11.56 a. m.	12.00 a. m.	4.	.50
18	11.58 a. m.	12.00 a. m.	2.	.75
24	1.29 p. m.	1.31 p. m.	2.	1.00
24	1.24.5p. m.	1.27.5p. m.	3.	.66
24	1.28.5p. m.	1.32 p. m.	3.5	.57
3 consecutive holes each 4 ft. deep	1.30 p. m.	1.45 p. m.	15	.80

The table gives only the time occupied in drilling the hole, the time occupied in changing from one hole to another being included only in the last instance, where the time was taken for drilling three consecutive holes each four feet deep. While the table shows the rate at which holes can be drilled with these hammer drills, still for general information as to what can be accomplished with an outfit of this kind per day, the results given previously in this article would be a better indication as to what to expect from drills of this kind.

The distribution of holes put in the rock for the purpose of blasting varied with the nature and shape of the rock to be excavated. Where the rock was fairly uniform in depth and level on the surface, holes were placed on each side of the trench every 18 ins., measured along the ditch. A hole was placed in the center of the

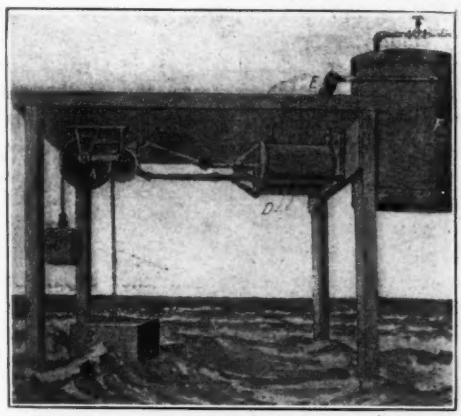
trench halfway between every alternate pair of side holes. Where there was less than one foot of rock to be excavated no side holes were drilled, the center holes alone being used to blast the rock. In some cases the center holes were omitted and the side holes were placed one foot apart. This arrangement of holes also gave good results in blasting. All holes were drilled 6 to 8 ins. below the grade of the sewer.

The holes were loaded with from 2 to 6 ounces of 60 per cent. dynamite. Four-ounce ⅞-in. sticks were used. This size stick of dynamite could easily be loaded in the holes drilled with the 1¼-in. drills. From 15 to 20 holes were loaded at once and connected into series with electric exploders and fired with a blasting machine. The blast broke the rock up so that it could be removed from the trench without further difficulty. The blasts were protected by laying a lattice made of 2-in. plank over that portion of the trench where the shot was to be fired, and a number of wooden poles were piled on the lattice, all of which was chained together with two log chains. Covering the blasts in this way proved a very effective way of protecting the blasts, and kept the broken rock from flying out of the trench.

The average cost of the rock excavation, including drilling, explosives, and removing the rock from the trench was $3.40 per cu. yd. In computing the rock yardage the trench was assumed to be 2-ft. wide.

THE SAND BLAST A LUXURY OF THE BATH

The very latest fad of the smart Parisienne is the sand bath, which she finds invigorating and beautifying. A few bushels of fine sea sand is brought to her room and slightly warmed before being spread out on a wide sheet. An energetic maid rubs her body all over with sand paper, turning her attention particularly to knees and elbows, which easily become roughened. After this process soft rich cream is massaged into the skin. Then the bather stands in the middle of the sheet and taking up handfuls of the sand she rubs it over her body till she is glowing with the friction. Then she reclines at full length on the sheet, the ends of which are folded over her, and rests several moments before rolling over and over so as to become completely immersed in the sand. Following this comes the hardest precess of the sand bath. It is called the blow bath and corresponds somewhat to the shower of a Turkish bath. From a sort of fan shaped blower sand is whirled out briskly so as to strike the body as forcibly as the bather can stand it. The effect is said to be wonderfully stimulating, and the sting is not unlike that produced by electricity. The sand brushes off the body easily and simply. The feeling of cleanliness and freshness following the bath is declared to excel the after effects of any water bath.



A COMPRESSED AIR WAVE MOTOR

The half tone here reproduced from the *Scientific American* will fully explain itself. Some poor fellow has "invented" another wave motor. The float is counterbalanced by the weight and rises and falls as acted upon by the waves. This rotates a shaft which is geared to a crank shaft and the cranks work the pistons in the compressing cylinders which deliver the compressed air to the receiver. The description of the apparatus informs us that "the cylinders are left open at one end, and no inlet valve is provided other than the piston washer."

AIR LIQEFACTION AND THE EXTRACTION OF OXYGEN

By Cecil Lightfoot.

The action of the Linde machine for air liquefaction is based on the refrigerating effect resulting from the expansion of air from a higher to a lower pressure, and which is due to the performance of internal work. At ordinary temperatures, this reduction in temperature amounts to about three-tenths degree

C. for each atmosphere of difference in pressure. It is, therefore, too insignificant to produce liquefaction of air at a single expansion, since this only takes place below —140 degrees C, (critical temperature of air) and at —191 degrees C. at atmospheric pressure, this being the boiling point of liquid air.

In the Linde machine the action of any desired number of expansions is accumulated and intensified by causing each preceding expansion to act as a fore-cooler to the air for the following expansion. This is attained by adopting the principle of heat interchange, which is, in this case, most efficiently applied by employing concentric tubes placed one inside the other and coiled in spiral form. The compressed air flows from top to bottom through the inner tube of the vertical double coil, expands through a valve between the inner and outer tubes from the bottom to the top, transmitting the cooling effect produced by expansion to the compressed air flowing down the inner tube. As a result the temperatures of the air before and after expansion are continuously reduced to the temperature of liquefaction, and part of the expanding air will collect in the liquid state in a vessel situated at the lower end of the heat-interchanger.

As the refrigerative action of the apparatus depends upon the difference of pressure before and after expansion, while the work of compression corresponds to the ratios of these pressures, the advantage of selecting a large difference in pressures, but a small ratio of pressures is apparent. In the machine herein described, the greater part of the cooling effect is produced by the expansion of air at an initial pressure of about 200 atmospheres to a pressure of 20 to 50 atmospheres, so that, according to the size of the machine, the difference of pressure is about 150 to 180 atmospheres, while the value of the ratio varies approximately from four to ten. Only the small quantity of air requisite for the primary charge and its subsequent renewal is introduced into the cycle from the surrounding atmosphere, leaving it again partly as liquid and partly as gas at atmospheric pressure.

The Linde machine for the liquefaction of air consists of the following parts: the heat-interchanger; the air-compressing plant; and appliances for the preliminary cooling and drying of the compressed air. The heat-interchanger consists of a triple coil composed of copper tubes placed one within the other. The cycle for air is performed, as already described, by causing air compressed to 200 atmospheres to flow downward through the innermost coil, at the lower extremity of which it is allowed to expand to an intermediate pressure of 20 to 50 atmospheres. The expanded air is then returned through the annular space between the innermost and middle coils to the top of the interchanger, when it is again compressed up to 200 atmospheres pressure and the cycle is repeated. By means of regulating valves, when the operation of the machine has been brought to a state of equilibrium, a small quantity of air is allowed to escape at atmospheric pressure, a corresponding amount being introduced into the cycle from the surrounding atmosphere. Part of this air leaves the second regulating valve in the liquid-air state and is collected in a vessel; the remaining portion is returned to the atmosphere through the annular space between the middle and outer coils. The liquid air is drawn from the collector by means of a small cock.

In the larger installations the necessary compression of the air is effected by means of a high-pressure air pump, which is usually arranged for two-stage compression, working in conjunction with a single-cylinder low-pressure air pump. The high-pressure cylinder of the former draws the partly expanded air from the heat-interchanger at an intermediate pressure of about 50 atmospheres, and compressing it up to about 200 atmospheres pressure, delivers it to the interchanger again, through a cooler. The air which is to be added to the cycle as "make-up" is supplied by a low-pressure air pump, which draws it from the atmosphere, compresses it to a pressure of about four atmospheres, and delivers it to the low-pressure cylinder of the high-pressure air pump, where it is compressed to a pressure of about 50 atmospheres. At this pressure it enters the high-pressure cylinder, together with the partly expanded air from the heat-interchanger. Regulation of the several pressures is performed with the aid of pressure gauges by means of the regulating valves in the heat-interchanger. Safety valves are provided to prevent the maximum pressures being exceeded.

The duty of air-liquefying plants is considerably augmented by a preliminary cooling of the compressed air prior to its entering the

heat-interchanger. For this purpose a fore-cooler is provided, by means of which the compressed air is reduced in temperature to —12 or —15 degrees C. by filling the receptacle provided for the purpose with a suitable freezing mixture, such as ice and salt. With larger installations, the preliminary cooling is brought about by a small belt-driven refrigerating machine on the ammonia compression system. The adoption of fore-cooling is advisable in all cases, but especially when the cost of power is an item of great importance. Between the compressor and the fore-cooler, apparatus is provided for separating water from the compressed air. This apparatus is provided with a suitable drain cock. Further extraction of the aqueous vapors from the compressed air in the smaller installations is effected after the last stage of compression by means of chloride of calcium.

The principle of the Linde apparatus for the production of oxygen from the atmosphere consists first of all in the complete liquefaction of the air to be resolved. The liquid air thus obtained is then passed through an interchanger, in which it acquires the necessary latent heat of evaporation by assisting in the liquefaction of a further supply of air, and is then subjected to a process of rectification. This rectification, which is very similar to the process employed in spirit refineries for the separation of alcohol and water, enables oxygen having a purity of 95 per cent. to be delivered from the apparatus. If the output be reduced by 10 to 20 per cent., the quality of the oxygen produced may be brought up to as high a degree of purity as 98 or 99 per cent.

The interchange of heat which takes place in the apparatus is so complete that before the by-product nitrogen is returned to the atmosphere so much heat has been removed from the incoming air that it leaves the bottom of the fore-cooler at a temperature considerably below freezing point, and then enters the top of the separator, passing downward through a series of coils, which are so constructed as to be surrounded by both the outgoing cold gases, i. e., both oxygen and nitrogen. The bottom of the separator contains liquid air, or more correctly speaking, liquid oxygen. The compressed air, on its way to the expansion point, is conveyed through this liquid, by which means it is largely condensed. It then passes through a regulating valve, at which point it expands, and it is ultimately discharged into the top of an inner central chamber which forms the rectifying column in which the separation of oxygen and nitrogen is effected, oxygen descending in a liquid state to the bottom of the separator, and nitrogen ascending in a gaseous or vaporous condition to the top. The nitrogen is allowed to discharge freely into the atmosphere through an extension of the fore-cooler, and the oxygen is allowed to boil off in any desired quantity by the adjustment of an oxygen discharge-valve. Both gases, however, as already stated, on leaving the separator are kept in intimate contact with the coils conveying the incoming air, so that before leaving the apparatus the heat of the incoming air has been mostly transferred to the gases. It will thus be seen that after equilibrium has been attained, the process is practically automatic.—*Electric Journal.*

AIR LIFT EFFICIENCIES

By F. A. Halsey.

[The following, from the Journal of the American Society of Mechanical Engineers, is a contribution to the discussion of the paper, "Tests upon compressed air pumping systems of oil wells," by Edmund M. Ivens, presented at the Washington meeting of the society and printed, in an abridged form, in Compressed Air Magazine, May, 1909.]

The air-lift pump is one of those things of which our knowledge is almost exclusively experimental. Its analysis presents such serious difficulties that rational equations for the performance of the apparatus have not been derived by anyone to my knowledge. Under these circumstances, we are reduced to experiment for the determination of the fundamental laws of the performance of the apparatus, and these experiments should cover a wide range in the conditions which lead to variation in the performance of apparatus, namely, depth of submergence and lift.

The most complete experiments now on record were presented in a paper before the British Institution of Civil Engineers in 1906, these experiments being of sufficiently wide scope to supply a satisfactory guide for the design of these pumps under a considerable range of conditions.

One curious feature attends the behavior of the air-lift pump and the Taylor hydraulic air

compressor, which are essentially the same apparatus, reversed in action. In each case we have a pair of vertical pipes communicating at the bottom, one filled with water and the other with a mixture of air and water—a sort of suds. If the pipes are of indefinite length the columns will take levels corresponding with their respective gravities, but if the suds pipe is cut off below this level it will overflow, the suds will rise, and we have an air-lift pump; while on the contrary, if the water pipe is cut off below this level, it will overflow, the column of water will rise, and we have a Taylor hydraulic air compressor. The point to which I refer is that while the first of these constructions has a low, the second has a high efficiency. The highest figure given in this paper for the efficiency of the pump is about 28 per cent., and while 40 per cent. has been reached in exceptional cases, the average is probably not more than 20 per cent. On the other hand, the efficiency of the hydraulic air compressor is in the vicinity of 75 or 80 per cent.

THE VENTILATION LAW FOR FACTORIES

The new law of the State of New York requiring a supply of fresh air for employes of workshops and factories reads as follows:

"The owner, agent or lessee of a factory shall provide, in each workroom thereof, proper and sufficient ventilation; if excessive heat is created, or if steam, gases, vapors, dust or other impurities that may be injurious to health be generated in the course of the manufacturing process carried on therein, the rooms must be ventilated in such a manner as to render them harmless, so far as practicable."

It must be obvious that a law so general in character, and so entirely lacking in specific requirements, should be supplemented by various data to secure intelligent and effective enforcement, and Mr. C. M. Ripley, in the September issue of *Machinery* does a good work in bringing together, as follows, various pertinent information relating to the subject.

Mr. William W. Walling, chief factory inspector for the State of New York, interprets the law as follows:

"As defined by Dr. John S. Billings, perfect ventilation means that any and every person in a room takes into his lungs, at each respiration, air of the same composition as that surrounding the building, no part of which has recently been in his own lungs or those of his neighbors, or which consists of the products of combustion generated in the building, while at the same time he feels no currents or drafts of air, and is perfectly comfortable as regards temperature, being neither too hot nor too cold. How much air is required to meet these conditions? Not less than 2,000 cubic feet per hour for each person, with the same amount per hour for each cubic foot of gas consumed, whether for light, heat or power."

IS THIS AMOUNT ARBITRARY?

Some landlords in New York City have put forth the claim that the amount of fresh air specified by the Department of Labor is an "arbitrary quantity." Several authorities on the subject of ventilation who have been consulted in the matter and who are also entirely disinterested agree that 2,000 cubic feet per hour per person is common practice and is based upon definite laws or rules which have been followed for many years in the design of ventilating systems.

The Architects' and Builders' Pocketbook, compiled by Mr. Frank E. Kidder, states that 1,800 cubic feet per hour per child should be the standard for school buildings, this amount being required by law both in Massachusetts and New York. It further states that in buildings more closely packed, and occupied for a longer period, the air supply should be from 2,000 to 2,500 cubic feet per hour per person. In giving an example of a school-room of certain dimensions, he shows that the standard amount of air would result in the air in the room being changed about eight times per hour, which certainly does not appear to be an excessive amount.

Since the above applies only to buildings where people sit quietly, or for buildings where only children congregate, it is difficult to see how the New York Department of Labor can justly be accused of an "arbitrary" action.

Mr. Percival Robert Foses, consulting, heating and ventilating engineer of New York City, states that he has found the rate of 2,000 cubic feet per hour per person a satisfactory and conservative working basis. This was used in designing the ventilating equipment of the large department store of B. Altman & Co., in the Rikers Island Penitentiary, in the Baltimore Stock Exchange, and in the new

Hearst Building at San Francisco, as well as in others; and he stated that the operating expense for a system laid out on this basis has not been found excessive.

EXAMPLE OF A LOFT BUILDING.

In a loft 25 feet wide and 100 feet long, containing 80 workmen, and lighted with electricity, the amount of air required would be 80 times 2,000 = 160,000 cubic feet per hour. This amount of air per hour would move at the rate of about ⅛ mile per hour, and would be sufficient to change the air in the loft six times per hour, assuming a ten-foot ceiling. Since the Massachusetts and New York State laws for school rooms require eight changes per hour, and since some authorities recommend even 50 per cent. in excess of this, it appears that the action of the factory inspector hardly comes within the definition of the word "arbitrary."

GAS LIGHTING.

Dr. Daniel R. Lucas, of New York City, states that it is a well-known law of hygiene that one gas jet will consume as much oxygen as five persons. Since electric lighting, thanks to the new high efficiency lamps, has been reduced in cost 50 per cent. or more, it appears that the easiest way to comply with the labor law regarding ventilation would be to abandon gas lighting.

Since the vitiating effect on the air of the average gas light is equivalent to that of five persons, it can be readily seen that the ventilation required will be reduced 5-6 by abandoning gas light, assuming one gas jet to each workman, or, stating it in another way, the landlord who clings to gas lighting must install ventilating apparatus six times as large as would be necessary if electric light were used. This calculation also is based upon conditions where one gas jet is provided for each workman.

OPERATING COSTS.

The operating cost for a ventilating system is made up of two items: (1) Power for turning fans; (2) Additional heat for incoming air. In a loft building where the tenant will pay for the power, and the landlord will pay for the extra heat required, since heat is included in the rent, the expense will be divided automatically. It will here be noticed that the adoption of electric lighting will cut down the operating expenses to a remarkable degree. This cut in expenses will benefit the tenant, since a much smaller ventilating motor will be required, and it will also benefit the landlord because less air will have to be drawn in, and hence the cost for heating will be diminished.

In large systems the services of an expert heating and ventilating engineer would probably prove valuable, and it is possible to so design the equipment that a judicious "recirculation" of the air from halls and basements will effect an economy in the fuel bill. This air is seldom impure and requires much less heat than if cold air were brought in from outside. It is also possible in buildings where high pressure steam is available, or where boilers which have been run at low pressure steam can be run at a high pressure, to adopt the following policy: Provide steam engines to operate the fans and turn the exhaust steam into the heating coils, thus getting a double use of the steam and cutting down the electricity bill. This idea could be carried still further in many instances, and economies could be made (especially in the winter) by abandoning electric pumping, and again reducing the expense for electricity. This is the stock argument of the advocates of isolated plants, who contend that great economies result in buildings of a million cubic feet or more, if engines are installed and electricity is made on the premises. It is a fact that steam at high pressure contains only about 6 per cent. more heat than steam at low pressure. Thus the argument that electricity can be made and a building heated with exhaust steam, is advanced. The layman does not appreciate one very peculiar fact about steam: that at 5 pounds pressure it is only about 6 per cent. cheaper to make than at 100 pound pressure.

In the future it is probable that factories and loft buildings will be equipped with ventilating apparatus at the outset, with the ducts concealed in the walls and the fans located in the basement. A model building of this character has recently been completed at 37-43 West 26th street, New York City, in which the landlord at the time of construction had the ventilating system installed at his expense, after the design of a prominent consulting en-

gineer. Thus the cost of operating a system and the responsibility of maintaining it in good condition does not rest upon the tenant. At the present writing (June 17) we are informed that the owners of the West 26th street corporation have already rented eight out of the twelve floors, a flattering reception and appreciation of the advantages they have to offer.

IMPORTANCE OF PURE AIR IN THE INDUSTRIES.

In the report of the United States Bureau of Labor at Washington, D. C., it is shown that deaths among factory workers due to consumption were divided as follows:

Employes exposed to metallic dust	36.9 per cent.
Employes exposed to mineral dust	28.6 per cent.
Employes exposed to vegetable fiber dust	24.8 per cent.
Employes exposed to animal and fiber dust	32.1 per cent.

It was also shown that the highest consumption mortality existed among operators of grinders, and 49.2 per cent. of all deaths were from that disease.

An ingenious conclusion was reached by Mr. Frederick L. Hoffman of the Prudential Life Insurance Co., based on this report. It is his opinion that by intelligent methods of ventilation and dust removal the consumption death rate among the wage earners could be so reduced as to result in an annual saving of 22,238 lives. This would add, quoting the *Engineering News,* "15.4 years of life for every death from consumption avoided by rational conditions of industrial life." Such a gain would represent a total of 342,465 years of additional life, and by just so much the industrial efficiency of the American nation would be increased. Placing the economic value of a year's life time at only $200, the total average gain to the nation would be $3,080 for every avoidable death of a wage earner from consumption, representing the enormous total of $68,493,000 as the annual financial value clearly within the range of practical attainment. Therefore nothing within reason should be left undone as a national, state, individual, or social duty to prevent that needless but now enormous loss of human life from consumption due to the unfavorable conditions in American industry.

THE DESTRUCTION OF RATS WITH CARBON DISULPHIDE

M. de Kruyff, of the agricultural bureau of the Dutch Indies at Buitenzorg, Java, has published an interesting article on the destruction of rats. After working four years with numerous viruses without succeeding in creating an epidemic or even killing a single rat, De Kruyff obtained more encouraging results by employing carbon disulphide in the following manner: All visible ratholes were first stopped with earth for the purpose of ascertaining which holes were inhabited, for the inhabited holes were found reopened on the following day. Half a teaspoonful, or less, of carbon disulphide was poured into each of these holes and, after waiting a few seconds to allow the liquid to evaporate, the mixture of vapor and air was ignited. The result was a small explosion which filled the hole with poisonous gases and killed all the rats almost instantly. A pound of disulphide, costing about 10 cents, is sufficient for more than 200 ratholes; 131 dead rats were found in 43 holes which were opened after the operation. In two cases, 10 rats were found in a single hole.

GRAPHITE FOR AIR COMPRESSORS

Graphite prints the following from a correspondent:

It has been a long time since I wrote you about graphite (seven years, I think), but I have been using it daily all these years nevertheless. I have had charge of an air compressor for lifting water by the air lift system, for the Gulf, Colorado and Sante Fe R. R. at this place, for the past ten years, and in all that time I have used a mixture of valve oil and graphite in the air cylinder, and to-day, after ten years use, the air cylinder is in as good condition as the first day it was started ten years ago. The air cylinder has never been rebored in all that time, and the rings in piston are perfectly tight. I have used graphite and oil on other parts of the engine during the past ten years, and the engine is in good condition at the present writing, never being overhauled in that time. I occasionally allow the machine to "inhale" a little dry graphite through the inlet valves.

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THE INTAKE PRESSURE IN AIR COMPRESSOR CYLINDERS

The types have an inveterate spite against us, and all too frequently they succeed in making an absurdity of what we intended for an intelligible sentence. In the issue immediately preceding this, on page 5442, eleventh line from the top, "this *use* of temperature" should of course have been "this *rise* of temperature."

The article in which this substitution was perpetrated bore the same title as above, and touched upon the possible cause of the high and theoretically impossible intake pressure often noticed in the indicator cards of air compressor cylinders at the precise moment when the intake ceases and compression is about to commence. It occurs to us that an additional suggestion as to the explanation of this phenomenon may be found in a concrete example from actual practice.

Say that we have a compressor with air cylinder 24 in. diameter by 36 in. stroke running at 60 revolutions per minute, giving the piston a travel of 360 feet per minute. The action of the crank will make the actual piston speed at the middle of the stroke 565 feet per minute, and this speed comes down to nothing at the end of the stroke. That is, the speed of the body of air which follows the piston on its intake side rises from nothing to 565 feet per minute in one quarter of a revolution of the crank or in one quarter of a second, and then the air movement comes down to nothing in the next quarter of a second, and so on continually. If the air comes through a pipe from outside the compressor room, its diameter being one third that of the cylinder or one ninth of the area, then for the air in the pipe, to follow the piston at its highest speed it must travel $565 \times 9 = 5085$ feet, or very nearly a mile a minute, and every quarter of a second the inrushing column of air must change its speed from zero to this mile a minute, or vice versa. Air has weight and inertia and it requires power to move it, and greater power to move it at accelerating speeds. The air enters the cylinder, following the piston, on account of the difference of air pressure between the normal atmospheric pressure outside the cylinder and a somewhat lower pressure within the cylinder, this lower than atmospheric pressure in the cylinder during intake being correctly

reported by the indicator card. As a certain difference of pressure between the outer and the inner ends of the intake column is absolutely required to start and to accelerate its movement, so also the retardation and stoppage of the inrush cannot occur without a reversal of the difference of pressures, the difference in this case being due to an excess of pressure within the cylinder above the normal pressure outside, and when the indicator card makes its report of this excess of pressure we may accept it not only as correct but also as adequately accounted for.

VALUE OF THE AFTERCOOLER

By Howard H. Bliss.

While reading Frank Richards' article on "Air Receiver Practice," in a recent number, [Compressed Air Magazine, Oct., 1909, page 5419], I became curious to know what proportion of the moisture contained in compressed air could be got rid of by the expedient of cooling the air thoroughly and allowing plenty of time for the mist to settle and be drained off. To investigate this I assumed the following problem:

Taking saturated air at 72 degrees Fahrenheit, compressing it to 150 pounds per square inch absolute, cooling it in an aftercooler to 72 degrees and allowing it to stand until no free moisture remains suspended, how much water is removed per pound of air? If the entire water content of the air were carried through the system and the air used in a drill taking 100 cubic feet of free air per minute, how much more water would be released to clog the exhaust than if the drill were run with air dried as in the first case?

According to Kent (page 484, edition of 1898), one pound of free saturated air contains 0.0168 pound of water at 72 degrees. When this pound of air is compressed to ten times the original pressure and the temperature is brought back to 72 degrees, the volume of the air, by Boyle's law, will be one-tenth of the original volume. The weight of water which can exist as vapor in one cubic foot of air is independent of the pressure of the air and depends only upon the temperature; therefore there can be now only one-tenth as much vapor in our pound of air as there was at first—nine-tenths of the 0.0168 pound will have become mist. Hence, the answer to the first question is, nine-tenths of 0.0168 or 0.0151 pound. The water remaining as vapor is 0.0017 pound.

To get an answer to the second question an assumption must be made as to the temperature of the exhaust. It may be taken at 0 degree Fahrenheit. Then, by Kent's table, the vapor in one pound of exhaust air amounts to 0.0009 pound. All the rest of the water present will be frozen as it passes out. So in the case where the compressed air is cooled and the water drained off the ice in the exhaust would weigh

$$0.0017 - 0.0009 = 0.0008$$

pound for each pound of air. When none of the moisture is removed from the compressed air the ice in the exhaust will weigh

$$0.0168 - 0.0009 = 0.0159$$

pound per pound of air.

Each cubic foot of free air at 72 degrees weighs 0.0747 pound, so that the drill using 100 cubic feet per minute takes

$$100 \times 0.0747 = 7.47$$

pounds per minute. The ice formed in the exhaust each minute would be

$$7.47 \times 0.0008 = 0.006$$

pound for the dried-out air, and

$$7.47 \times 0.0159 = 0.119$$

pound for the undried air. Hence, the process of aftercooling and allowing the water to settle out saves

$$0.119 - 0.006 = 0.113$$

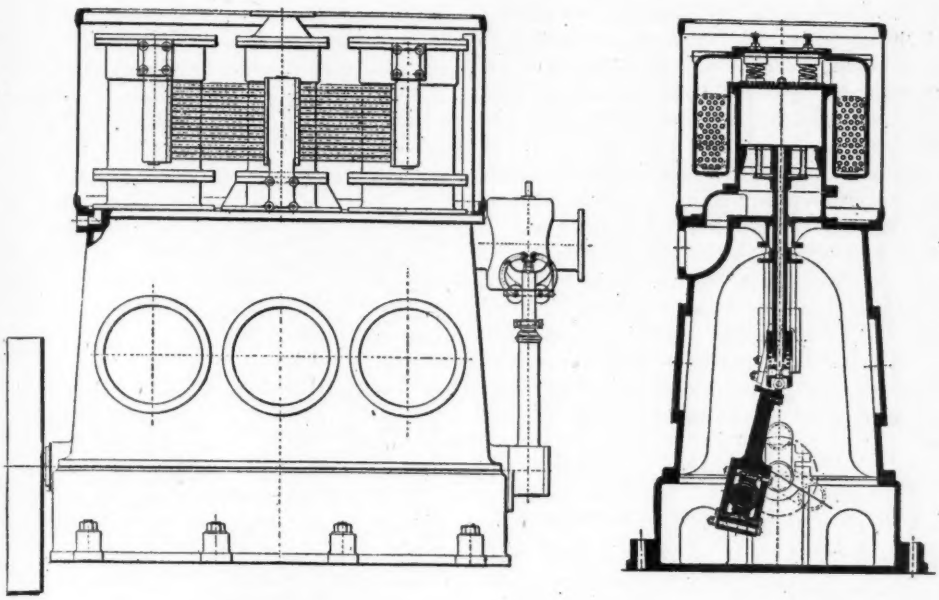
pound of ice in the exhaust every minute. The proportion of ice in the two cases is 0.006 to 0.119, or 1 to 19.8.—*Power and the Engineer.*

FLIGHTS OF THE WRIGHTS

On October 2, in a flight by Orville Wright at Potsdam, Germany, a height of 1,600 feet was reached. The height was estimated only with a rough approximation by noting the time required for the ascent, 15 minutes, the descent being made in 5 minutes. A pocket aneroid would have indicated the height attained very satisfactorily.

On October 4th Wilbur Wright made a notable flight from Governor's Island up the Hudson River, passing over the anchored warship of England, France, Germany, Italy, and the United States, assembled for the Hudson-Fulton celebration, passing around the tomb of General Grant and landing neatly at Gov-

ernor's Island again. The distance traversed was about 20 miles and the time of flight was 33 minutes. As the aeroplane passed our window, which is about 200 feet from the ground it just covered the top of a chimney of a somewhat greater height on the other side of the river.



THE SCOTT AIR COMPRESSOR

The cut herewith, reproduced from *The Engineer*, London, gives the essential particulars of an air compressor embodying several novel and interesting features as recently exhibited at the Gloucester show of the Royal Agricultural Society. It is a power driven machine with three vertical single acting cylinders, two for low pressure and the middle one for the high pressure. The water jacket which encloses all the cylinders is traversed by a series of tubes which serve as an efficient inter-cooler between the compression stages. The discharge valves consist of a considerable number of steel balls, such as are used for ball bearings, and each ball has a seat of its own in a steel plate, the lift being controlled by a guard plate the holes in which are pitched in between those on the lower plates. A large valve opening is secured while the balls lift only a sixteenth of an inch or so, while springs and other complications are avoided. The air is admitted to the cylinders through valves in the top of the piston. These valves are made of thin steel plates and they are operated by a rod which passes through the center of the piston rod. The lower end of this rod is fitted with a guide and roller and a spring for closing. The roller is moved by an adjustable hardened steel cam placed in the jaw of the connecting rod. As this connecting rod swings across the top center at the time when its horizontal movement is greatest and its vertical movement negligible, the cam causes the intake valves to open so rapidly that they are wide open before one-quarter of the stroke is made and are shut again when the piston reaches its lowest point of travel. The steel delivery valve plates form the top covers of the cylinders, and are held down by strong steel springs, which normally do not act when the compressor is running, but are provided to act as buffers in case the piston touches the cover.

One of the obstacles to mining on the coast of Africa is the malaria-carrying mosquito. Gold mining there depends for its success on the extermination of this pest by draining the lands and other sanitary measures.

PNEUMATIC ELECTRIC SEA SOUNDING

The sounding apparatus which until recently has been in use in the German navy consists of a glass tube closed at the top, silvered on the inside and attached vertically to a heavy sounding lead. When the tube descends the water rises within it, compressing the air according to the depth and at the same time dissolving off the silver, thereby registering the maximum depth. The operation is extremely simple, the objection being that for each record the tube must be drawn to the surface to have the silvering renewed.

For this is now being substituted an electric device in which the air tube is connected to a cylindrical member containing mercury and so arranged that the increasing air pressure causes the mercury to rise and submerge a pair of high resistance wires, the resistance varying according to the height of the mercury. The resistances can be read on board the vessel by means of wires which run down to the tube, giving constant indication of the varying depths.

A SCHOOL OF AERONAUTICS

A higher school of aeronautics has been established in France. The new school, which is due to the conception and efforts of Commandant Roche, will be concerned with the practical side of aeronautics and aviation, and the pupils who succeed in passing its examinations will receive the title of aeronautical engineer. The course will last a year, and the lectures will be devoted to all the principal branches of aeronautics and aviation, including motors, while additional lectures will be given on subjects concerned with the progress and evolution of aerial navigation.

COMPRESSED AIR IN THE COAL MINE

The advantages of compressed air at the coal face over every other form of motive power, in fiery, dusty or hot mines, cannot be overestimated, absolute safety being assured in the most dangerous and gassy mine. The escaping air clears out the dust, assists in ventilation, and also cools the air in the workings; the importance of this last will be appreciated by those who have spent any time in a hot mine.

THE MOTOR-DRIVEN COMPRESSOR

The steam-driven compressor has still a useful field before it for colliery work, as under certain conditions it may prove the best, if not the most economical, unit, but it is in the motor-driven compressor that we most nearly approach the ideal power for driving auxiliary machines at the coal face in a dangerous mine. Such compressors may be placed out of the way, but as near to the coal face as safety will permit, the advantages of this arrangement being a flexibility of power almost equal to electricity, a higher factor of safety, and a multiplicity of small motors done away with.—*Iron and Coal Trades Review.*

Size of Tires		Maximum lbs. Weight per Tire	Actual Weight per Tire	Lbs. Inflation Pressure Required
Metric	American			
	30 x 3	500	300 lbs. to 400 lbs.	50
	28 x 3		400 lbs. to 500 lbs.	60
710 x 90	28 x 3½	700	400 lbs. to 600 lbs.	60
760 x 90	30 x 3½			
810 x 90				
840 x 90	32 x 3½	800	600 lbs. to 700 lbs.	70
870 x 90	34 x 3½		700 lbs. to 800 lbs.	75
910 x 90	36 x 3½			
765 x 105	30 x 4	850	650 lbs. to 800 lbs.	60
815 x 105	32 x 4	1,000	800 lbs. to 950 lbs.	70
875 x 105	34 x 4	1,100	950 lbs. to 1,100 lbs.	75
915 x 105	36 x 4			
820 x 120	32 x 4½	1,100	700 lbs. to 900 lbs.	60
			900 lbs. to 1,100 lbs.	70
880 x 120	34 x 4½	1,300	1,100 lbs. to 1,300 lbs.	80
920 x 120	36 x 4½			
895 x 135	34 x 5	1,400	1,000 lbs. to 1,300 lbs.	70
936 x 136	36 x 5	1,600	1,300 lbs. to 1,600 lbs.	80

AIR PRESSURES FOR PNEUMATIC TIRES

The proper and sustained inflation of the tires of automobiles is a detail of operation which is of the greatest inportance. It not only minimizes the vibration of the machine and adds to the comfort of the riders but it is necessary for the preservation of the tire. If the tire is not inflated with a sufficient pressure, so that it stand up full and round under its load, then as it travels along the material of it is subject to abnormal bending, and, on account of the thickness, this bending upon itself constantly reversed makes internal friction and chafing, and the tire is soon actually worn out by its own internal friction.

The manufacturers of tires have done an important service—both for themselves and their customers—in publishing tables of tire sizes and air pressures, and these it is quite necessary to approximately follow if satisfactory results are desired. The figures given by the different makers vary, as might be expected, but the following by the Michelin Tire Company seems to represent good average practice.

TUNNELING

As the United States continues to grow in wealth and importance, tunneling operations increase in like proportion, both in number and in magnitude. New York city and its environs are now underlaid by a network of tunnels, and other cities are rapidly developing underground systems, since through the increase in population business and travel become congested. All over the United States water supply, hydro-electric power, and the reduction of grades on railways are requiring new and expensive tunnels, to which, in the West, are added the great irrigation tunnels called for in both Government and private enterprises. The result of all this activity in tunneling has been a vast improvement in both machinery and methods, and a greatly increased number of thoroughly trained and skilled workmen, so that records formerly unattainable in the United States are now being made in widely separated localities.—*Presidential Address, Spokane Meeting Am. Inst. Mining Engineers.*

MEASURING THE AIR

As the use of compressed air increases it becomes more and more necessary to be able to measure the actual volumes of air which are compressed and delivered by different machines, so that their volumetric efficiencies and actual economies may be accurately determined, and also in the use of the air by different apparatus or in specific operations it is equally desirable to know the volumes of air employed. As to compressor efficiencies the filling of tanks of known capacity may do for laboratory investigations of small compressors, but the method cannot be considered practical and is of limited application at the best.

What is wanted is an apparatus which can be connected to compressed air piping wherever desired and which will give a continuous and permanent record of air passing through at whatever pressure, reporting the same, for uniformity and convenience, in volumes of free air. This is claimed and guaranteed to be done by the St. John Indicating and Recording Air Meter advertised in this issue. It is applicable to air, gas or steam; it records continuously the cubic feet of free air or gas used during each hour of the day, and a permanent record is made by it for the hour, day or month, so that where it is used the actual air consumption and the cost of it may be known.

A LIFE SAVING CANNON

Wrecked vessels are usually unprovided with any means of throwing a life line to shore, but the new apparatus brought before a British committee of experts by A. J. McLeod, of West Hartlepool, is designed especially for use from the ship. It is a cannon, with a barrel five feet long mounted on a four-wheeled carriage. Compressed air is the propelling power and a crank wheel on each side gives a means of quickly generating by hand sufficient energy to throw the line carrying projectile half a mile. A special check keeps the line from unwinding from its winch so rapidly as to become tangled. In the trials made this apparatus seems to have proved more efficient and to have a longer range than the ordinary rocket, and, as it uses no explosive, it can be employed without risk of firing any combustible or explosive cargo. Line firing from the vessel has a number of advantages. The apparatus is promptly at hand, the wind is usually toward shore and the land is a much better target than the life savers have when working from shore.

IRRIGATION TRANSFORMATION

Within the confines of that vast region which our early geographers marked as the Great American Desert, and which Webster and Clay described as an uninhabitable and worthless waste, probably 13,000,000 acres have been reclaimed by irrigation, and homes for half a million families have been provided on farms. Irrigation canals representing an investment of $150,000,000, and long enough to girdle the globe with triple bands, have spread oases of green in sixteen arid states and territories. An annual harvest valued at not less than $250,000,000 is the desert's response to the intelligent application of water to her sunburned valleys. Practically all of this stupendous miracle has been wrought within the past quarter of a century, and a large part of it by individual enterprise. The Great American Desert no longer calls up a vision of desolation and horror. With the westward march of settlers its boundaries have shrunken. Railroads have thrust its barriers aside. Its flowing streams, and its underground waters

are being measured and studied and we are beginning to grasp faintly a little of its potential greatness. Conservative engineers, on the basis of our present knowledge, estimate that not less than 30,000,000 acres are yet reclaimable by water from the streams which drain it.—*Farm Implements.*

LATEST U. S. PATENTS

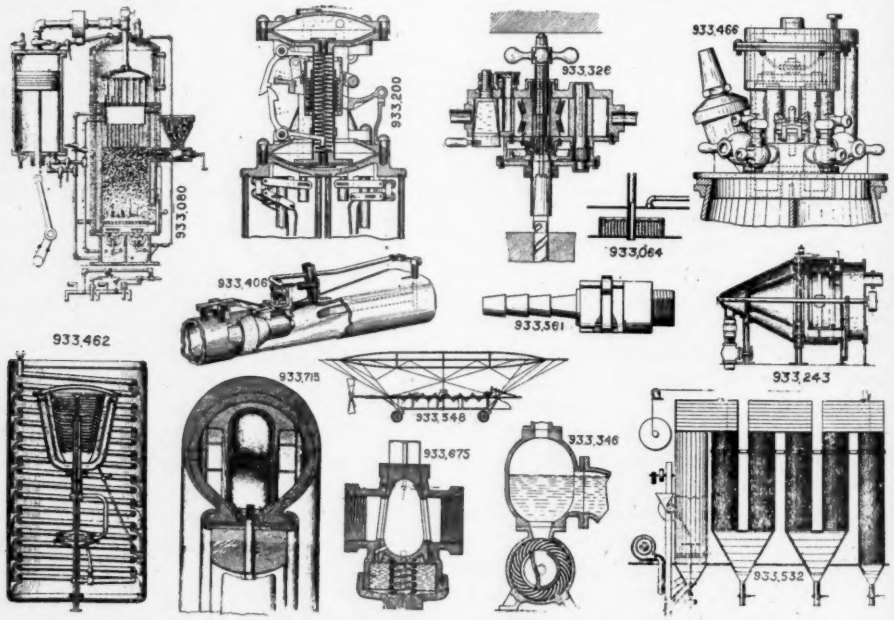
Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

SEPTEMBER 7.

933,064. CARBURETED-AIR APPARATUS. EDWARD B. DENNIE, Newport News, Va.
933,080. HEAT-ENGINE PLANT. SIMON LAKE, Bridgeport, Conn.
933,200. PNEUMATIC PUMP OR APPARATUS FOR RAISING WATER BY MEANS OF COMPRESSED AIR. THOMAS O. PERRY, Chicago, Ill.
933,243. APPARATUS FOR SEPARATING MIXED GASES. CHARLES J. A. FIESSE, Washington, D. C.
933,527. PNEUMATIC-DESPATCH APPARATUS. WILLIAM A. BROWN, Chicago, Ill.
933,532. APPARATUS FOR GRADING PULVERULENT MATERIALS. SIMON COOPER, New York, N. Y.
933,548. AEROMOTOR. SAMUEL H. GILSON, Salt Lake City, Utah.
933,551. PNEUMATIC HEEL-CUSHION. WILLIAM L. GORDON, Deal, N. J.
933,561. PNEUMATIC TOOL-COUPLING. ALEXANDRE HERBERT, Montpelier, Vt.
933,675. SELF-LUBRICATING AIR-COCK FOR ROCK-DRILLS. CARL SENN, Stocking, Cal.
933,715. PNEUMATIC TIRE FOR AUTOMOBILES AND OTHER VEHICLES. CHARLES A. LEWIS, Denver, Colo.

SEPTEMBER 14.

933,751. METHOD FOR MAKING SOUND METAL INGOTS AND OTHER CASTINGS. ROBERT A. HADFIELD, Sheffield, England.
933,793. ACETYLENE-GAS APPARATUS. COLEMAN K. SOBER, Lewisburg, Pa.
933,926. CLEANING APPARATUS. FRED J. SEELEY, Pontiac, Mich.
933,972. TRACK-SANDER FOR LOCOMOTIVES. JAMES E. GANSON, Columbus, Ohio.
933,991. PNEUMATIC SANDER. CHARLES F. KABISIUS, Salt Lake City, Utah.
934,019. FLUID-PRESSURE BRAKE SYSTEM. WILLIAM H. SAUVAGE, New York, N. Y.



PNEUMATIC PATENTS SEPTEMBER 7.

933,326. PNEUMATIC DRILL. MARTIN MCCUNE and JOSEF F. MELOUN, Cleveland, Ohio.
933,346. AIR AND GAS PUMP OR COMPRESSOR AND THE LIKE. WALTER SCHEURMANN, Newark-on-Trent, England.
933,366. DOUBLE-SCALE PNEUMATIC MUSICAL INSTRUMENT. THOMAS DANQUARD, New York, N. Y.
933,406. PNEUMATIC-TUBE SWITCH. EDWARD W. WALLACE, Detroit, Mich.
933,462. APPARATUS FOR SEPARATING OXYGEN FROM AIR. JOSEPH E. JOHNSON, Jr., Long Dale, Va.
933,466. MILKING-MACHINE. ROBERT KENNEDY, Glasgow, Scotland.
934,096. PNEUMATIC TOOL. ANDREW SCHUM, Mariah Hill, Ind.
934,107. METER. ALBERT H. TAYLOR, Easton, Pa.
934,138. FLUID-PRESSURE SWITCHING DEVICE. ROBERT V. CHEATHAM, St. Mathews, Ky.
934,293. SUPPLEMENTAL AIR-BRAKE MECHANISM. ARTHUR DOAN, Oakland, Cal.
934,323. GOVERNOR FOR AIR-COMPRESSORS. JOHN H. KLOER and DORSEY B. LEAVELL, Los Angeles, Cal.
934,418. CARRIAGE FOR PORTABLE PNEUMATIC DRILLS OR OTHER APPARATUS. RICHARD H. ROBINSON, New York, N. Y.

SEPTEMBER 21.

934,454. MACHINE FOR BOTTLING AND SYRUPING AERATED BEVERAGES. ALFRED E. MUNSON, Chicago, Ill.

934,504. METER FOR LIQUIDS AND GASES. FREDERICK N. CONNET, Providence, R. I.

934,514. BLOWPIPE. CORNELIUS D. FITZSIMMONS, Philadelphia, Pa.

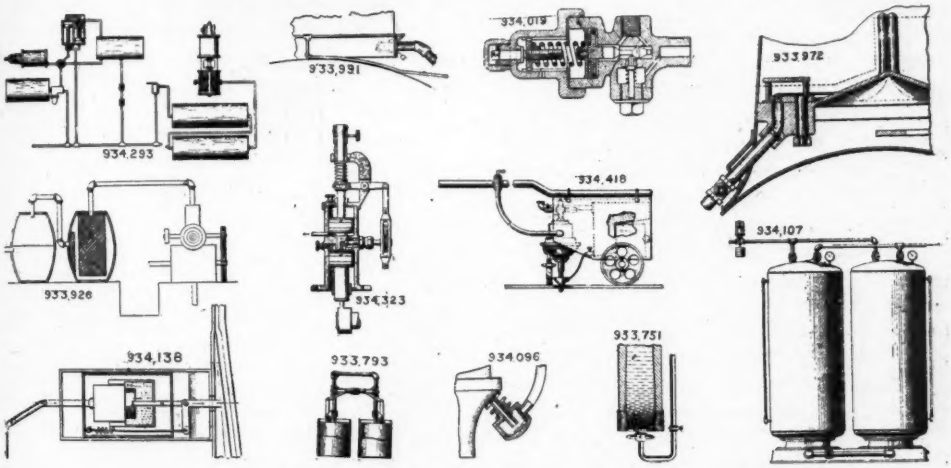
934,591. POISON-DISTRIBUTER. HENRY E. BRANDT, Chisago City, Minn.

934,628. PNEUMATIC JET FOR CONVEYERS. EARLEY W. RICE, Waxahachie, Tex.

934,640. PNEUMATIC TOOL. WILBER H. VAN SICKEL, Philadelphia, Pa.

934,647. CISTERN. OLIN M. ALEXANDER, Anniston, Ala.

1. In a cistern, a body, a pressure tank in the body, a valve establishing communication between said tank and body and arranged to close upon the establishment of pressure in the tank, a water-conducting pipe leading from the tank, a local air-compressor, a non-ventilating pipe independent of and at all times out of communication with the water-conducting pipe and establishing direct communication between said lo-



PNEUMATIC PATENTS SEPTEMBER 14.

cal air compressor and the tank, and a draw-off faucet interposed in the water-conducting pipe, said faucet affording means for venting said pressure tank.

934,650. WINDMILL. ALVA AYERS, Barberton, Ohio.

934,689. WINDMILL-GOVERNOR. LOUIS M. NELSON, Douglas, Wyo.

934,728. TRACK-LAYING APPARATUS. HENRY W. JACOBS, Topeka, Kans.

5. In an apparatus for constructing railroad track, the combination of a car having a motor thereon, a car having an air compressor thereon, an air reservoir also mounted on said last-mentioned car, track working tools adapted to be operated by compressed air, and connections between said reservoir and said tools.

934,785. COMPRESSED-AIR SIGNAL. ROBERT ARMSTRONG, Victoria, British Columbia, Canada.

934,838. APPARATUS FOR RAISING SUBMERGED SHIPS AND OTHER BODIES. BENJAMIN REINIER, Vidauban, France.

5. A caisson for refloating sunken ships and similar purposes having a double wall forming a hollow jacket which can be filled with water for submerging the caisson, and into which air may be forced for raising it, the center having a removable cover and being available for carrying goods.

934,879. PIPE-LINE SYSTEM FOR BREWERIES AND BOTTLING ESTABLISHMENTS. CHARLES L. BASTIAN, Chicago, Ill.

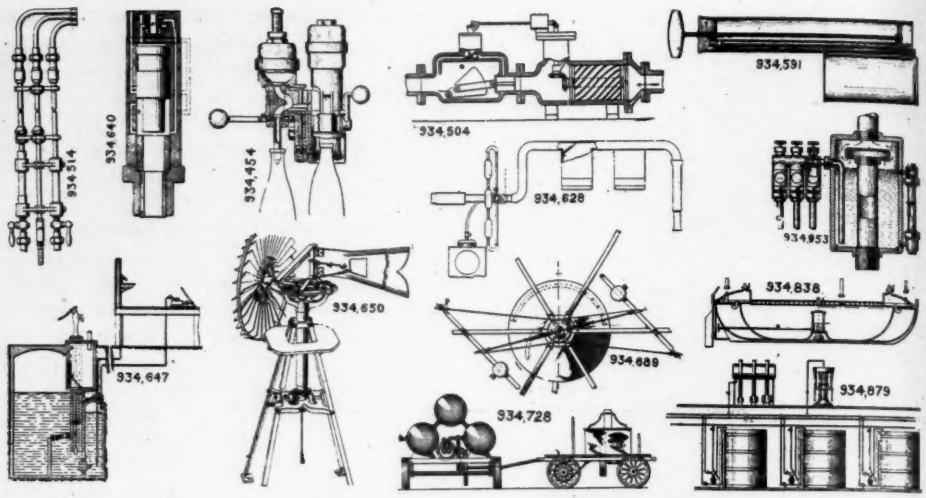
1. In a pipe line system for breweries and bottling establishments, the combination of a beer supply vat, a pipe connected to the vat at the bottom thereof and delivering beer to the head of a filling or racking machine, a pipe discharging into the vat at the top thereof for supplying air pressure upon the beer in the vat, and means controlled by the pressure of the beer outside the vat for automatically increasing the air pressure in the vat without disturbing the beer to compensate for the loss of pressure as the level of the beer is lowered during the filling operation and thereby provide for constantly delivering the beer to the head at a predetermined presssure without loss of gas.

934,953. LUBRICATOR. GEORGE E. WITT, San Francisco, Cal.

1. The combination with an air compressor, and a discharge pipe thereof, of a receiver with which the discharge pipe is connected, a check valve between the receiver and compressor, an oil reservoir interposed in the discharge pipe between the check valve and the compressor, said discharge pipe opening into the reservoir whereby the oil contained therein is subject to the pressure of the air, and feed pipe connection between the reservoir and the part to be lubricated.

934,956. METHOD OF DELIVERING LIQUID. CHARLES L. BASTIAN, Chicago, Ill.

1. The method herein described of delivering beer from a supply vat to the head of a filling or racking machine at a constant pressure and with evenness of flow during the filling operation to avoid agitation and foaming, which method consists in providing an initial air pressure above the beer in the vat which, together with the weight of the beer, is sufficient to deliver the beer from the bottom of the vat at a predetermined pressure to the head, and then increasing the air pressure above the beer in the vat relatively to the lowering of the level of the beer by the pressure of the beer outside of the vat and without disturbing the beer to compensate for the loss of pressure due to the withdrawal of beer from the vat, whereby to deliver all the beer in the vat to the head of the filling or racking machine at the same pressure and without the loss of gas.



PNEUMATIC PATE NTS SEPTEMBER 21.

SEPTEMBER 28.

935,039. FLYING-MACHINE. ALBERTO R. MALASOMMA, New York, N. Y.

935,048. COUPLING FOR THE INFLATING-VALVES OF PNEUMATIC TIRES. CHARLES McNELLIS, Chicago, Ill.

935,338. MILKING-MACHINE. WILLIAM J. UEBLER, West Schuyler, N. Y.

935,390. DAMPER-REGULATOR. RICHARD P. MITCHELL and ROBERT V. BRAWLEY, Statesville, N. C.

935,442. GOVERNOR. GEORGE H. WILSON, Spokane, Wash.

1. A governor, comprising a brake mechanism, an air pump, and a cylinder provided with an air vent and containing a resistance piston connected with and controlling the said brake mechanism, means whereby the movement of the piston to operate the brake will gradually close a vent, the said cylinder being connected with the said discharge of the said air pump to actuate the piston.

935,537. PNEUMATIC MOTOR. REINHOLD A. NORLING, Aurora, Ill.

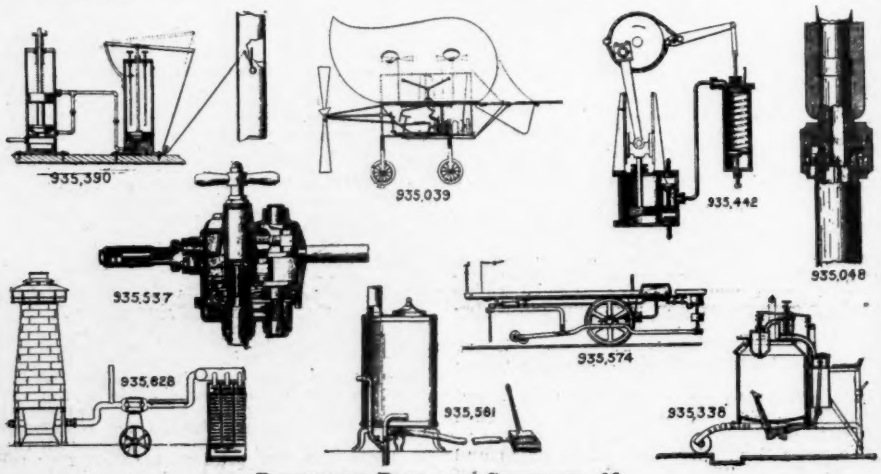
935,561. HYGIENIC HEATER. HENRY L. STUTTS, Green Hill, Ala.

935,574. CAR-FENDER. CHARLOTTE ARNESEN, Portland, Oreg.

1. The combination of a fender mounted for vertical movement, fluid pressure actuated means to operate the same, a movable releasing element in advance of the fender, fluid pressure actuated means to operate the releasing element, and means actuated by an initial movement of the releasing element, to put both the means for operating the fender and the means for operating the releasing element into operation.

935,628. METHOD OF OPERATING BLAST-FURNACES AND CONVERTERS. JAMES GAYLEY, New York, N. Y.

1. The method of operating blast furnaces or converters, using an air blast consisting in reducing the moisture content of the air to a small and substantially uniform percentage, supplying the dried air at a substantially uniform temperature and weight to blowing engines, and then forcing this air to the furnace or point of use; substantially as described.



PNEUMATIC PATE NTS SEPTEMBER 28.

NOTES

H. H. Stock, for many years editor of *Mines and Minerals,* has been appointed professor of mining engineering at the University of Illinois.

In the coal mining district near Barcelona, Venezuela, the coal is transported from the mines to the railroad, six miles, in kerosene boxes on burros.

The better grades of carbons for diamond drilling are selling at as high as $85 per carat. Fifty years ago they were worthless, and in the '70s sold at as low as $5 per carat.

T. Commerford Martin, for more than a quarter of a century editor of the *Electrical World,* recently resigned that position to accept the general secretaryship of the National Electric Light Association.

Small diamonds that used to be lost to the miners are now saved by passing the debris with the aid of water over a greased table. The grease holds the diamonds, while all other solid particles are washed away.

The American Society of Mechanical Engineers has accepted an invitation from the Institution of Mechanical Engineers to hold its spring meeting for 1910 in England, at such time and place as may be selected by the Institution.

Much railroad work would never be undertaken were it not that the shortening of a line, the lowering of a grade, or the improving of a roadbed, will allow the reduction of running time and thus often secure a mail contract.

The Lucin cut-off on the Union Pacific R. R. cost $10,000,000, reduced the length of the line 44 miles, eliminated more than 1,500 feet of heavy grade and 3,919 degrees of curvature, or more than 10 complete circles, and effected an operating economy of from $900,000 to $1,000,000 per year.

Sixteen tons of American eagles were received recently at Washington, D. C., in a single shipment. There were four of them, and they are to be placed over the state and carriage entrances of the new Union Station. Designed by Augustus Saint Goudens, they are each 8 feet high and the spreading wings measure 12 feet from tip to tip.

On one of the government railways in New South Wales, Australia, the construction of a new line eliminates a switchback, and secures easier grades and reduced curvature, although at immense construction cost. Five tunnels have been completed and five more are in progress. Electricity is used for lighting and for driving the air compressors.

An emergency respirator for use in mines has been invented by Mr. Clarence Hall, of the U. S. Geological Survey. The "respirator" consists of two cans, through one of which is drawn the air which is to enter the lungs. This air is here enriched with oxygen, generated by dropping water upon sodium peroxide. The exhaled breath passes through the other can, containing lye to absorb the carbon dioxide.

Prof. Charles Richet, of Paris, has devised a means for purifying the air in rooms. His apparatus is an air filter which mechanically sterilizes air. Very fine drops of glycerine are scattered along the walls of a cylinder containing a suction fan. Each particle of air drawn in by the fan is freighted with glycerine, and hence tends to drop, thereby carrying with it the germs, dust, and microbes with which it may be laden.

An unusual method of tunnel drainage was used by Mr. H. H. Dalrymple-Hay in the Hampstead tube of the London underground railways. The tunnel was built under air pressure and there was considerable leakage into it. Instead of putting in a pump Mr. Hay put down a well hole, 11½ in. in diameter, carrying it 210 ft. below the grade of the tunnel and terminating in a porous stratum. The hole was cased through the water bearing stratum surrounding the tunnel. It was found that 167 imp. gal. passed down the hole per hour.

Rubber is in such demand for modern uses that not only are new plants supplying it being sought, but eager efforts are being made to produce substitutes. Artificial indigo and ar-

tificial camphor are among the great successes of modern chemistry, and artificial rubber seems to be near at hand, as the production of caoutchouc by synthesis has been already announced by Mr. Allsebrook and Dr. Docherty of Burton-on-Trent, England.

After exhaustive tests, in which the power saving when operating at great depths was found to be as high as 50 per cent., the Homestake mine, of Leeds, South Dakota, operating the largest mechanical mining equipment in the world, has recently installed fifteen electric air drills. Several drills of the same type have been purchased by the Wenatchee Canal Company, and are now being used in driving the big tunnels just west of the Columbia river.

Editors generally will please put us on record as not wishing or asking any favor on account of being advertisers. We buy their space at the lowest possible price. Sometimes at a price so low they squeal, and we therefore appreciate any reading notices they are willing to give us, and they are free to chuck into the waste basket any of the "stuff" they think savors too strongly of an advertisement or is not of any possible interest to their readers.—*Graphite.*

Another line of railway, the fourth, across the Andes to the Pacific coast has been begun. It is from Arica, on the Pacific, to La Paz, in Bolivia, a distance of 292 miles, but rising to an altitude of 11,900 feet above sea level. The average gradient on the higher levels will be 4.5 per cent., with a maximum of 6 per cent., and at several places the railway will have to be worked on the rack system. There will be 48 bridges and 70 tunnels. A hydro-electric station is to be erected to generate sufficient power to run the trains to the summit, besides furnishing power and light for Arica.

Samples of air at a height of nearly nine miles have been recently obtained and examined for the presence of the rare gases. The collecting apparatus, carried by a large balloon, is a series of vacuum tubes, each drawn out to a fine point at one end. At the desired height an electromagnetic device, connected with each tube and operated by a barometer, breaks off the point of the tube, admitting the air. A few minutes later a second contact sends a current through a platinum wire around the broken end, melting the glass and sealing the tube.

The industry of aerial navigation is said to be developing in France with astonishing rapidity. There are in Paris in full operation 15 factories for the manufacture of materials and the construction of aeroplanes of all sizes, forms, and designs, besides a dozen or more inventors who are making under cover and more or less secretly individual machines which embody their special and more or less original ideas of what the aeroplane or dirigible air ship of the future ought to be.

In an article in the *Elektrotechnische Zeitschrift* Mr. L. Zehnder discusses the danger turbances, and the methods of avoiding disto ballons and aeroplanes of electrical disastrous effects. He points out that the electrical conditions of the air are subject to great variations during thunder storms and that the atmospheric charges may change suddenly in sign. In clear weather an ordinary balloon without metal parts is not exposed to any danger so long as it floats in the air; but in the modern dirigibles much of the framework consists of conducting materials, which add to the danger. Also a balloon may be charged with electricity and a spark produced when contact with the ground is made, setting fire to the gas.

Many unsuccessful attempts to produce a non-inflammable celluloid have caused new substances of the kind to be received with skepticism, but it is claimed that the cellite of Dr. A. Eichengrun, now made at Dusseldorf, Germany, has withstood tests proving it to be a cheap and useful material. Celluloid is a mixture of collodion cotton, a nitro-cellulose less highly nitrated than guncutton, with camphor and suitable coloring matters. In cellite the nitro-cellulose is replaced by an acetyl-cellulose, made with acetic acid instead of nitric acid, and variety is given to the product by substituting different artificial camphors for ordinary camphor. Cellite is thus made soft, hard, elastic or flexible. It is slow burning, with none of the explosive combustibility of celluloid.

COMPRESSED AIR MAGAZINE

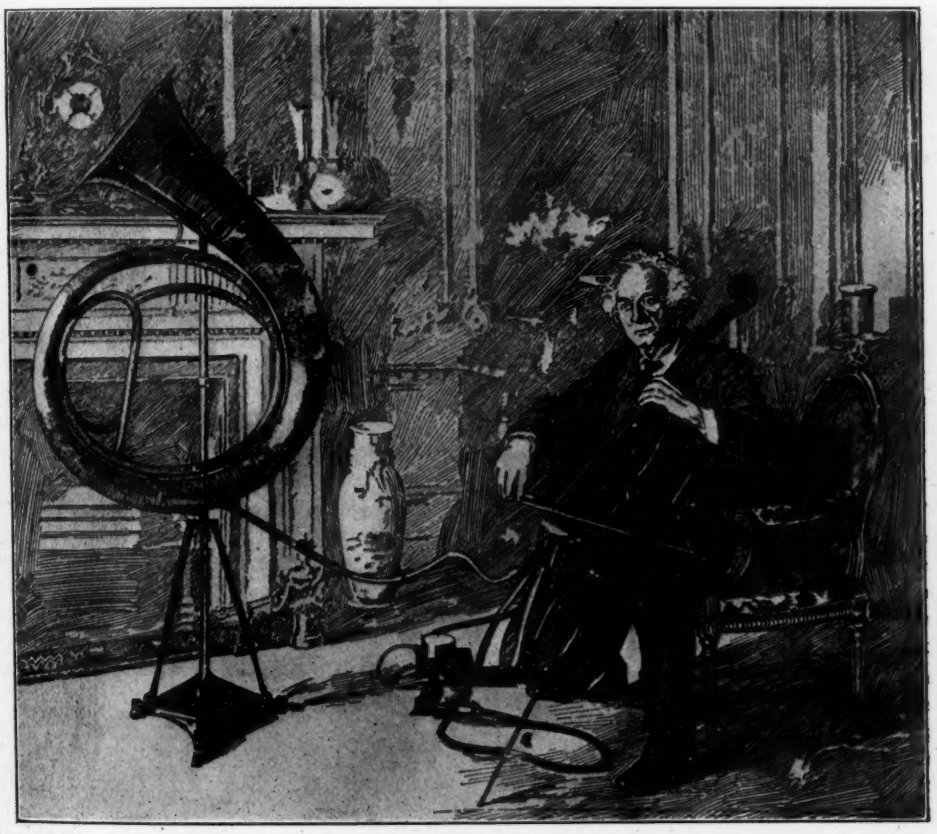
EVERYTHING PNEUMATIC.

Vol. XIV DECEMBER, 1909 No. 12

THE AUXETOPHONE OR MUSIC MAGNIFIER, COMPRESSED AIR THE AGENT

The auxetophone, the invention of Hon. C. A. Parsons, of steam turbine fame, was exhibited at a recent concert in London. The cut (from Popular Mechanics) shows it as it appears in use. It is an attachment for musical instruments which by the aid of compressed air increases the volume and intensity of tone while retaining all the characteristics of the instrument. The following description is furnished by the English correspondent of the Scientific American:

The auxetophone may be best described as a



THE AUXETOPHONE.

comb or multiple-reed valve of aluminum, which comb is hinged in such a manner that each tooth of the comb can vibrate at a variable distance from a corresponding slot in a little box to which compressed air is supplied at about five pounds pressure. The farther away the teeth are from the slots, the greater is the flow of air, and *vice versa*. The flow of air is controlled by a valve, and when caused to vibrate, the air transmits corresponding sound waves into the trumpet.

When the auxetophone is applied to the cello or any other stringed instrument, the valve is connected by a rod of aluminium with the bridge of the instrument. Thus the valve is caused to vibrate in accord with the characteristic tone of the instrument. The sound issuing from the trumpet, though in many respects identical with that of the instrument itself, is at the same time richer in character and greater in volume.

A special bar is carried across the sounding box of the instrument to support the multiple-reed valve and its box. The current of compressed air enters the box at its lower end. The aluminum connecting rod between the valve and the bridge of the instrument is clearly shown.

The air is compressed in a small portable cylinder. The current first passes through a pressure gage at the player's foot, the dial of which can be instantly and easily read and followed. From the pressure gage it passes to a small air filter, which removes all suspended impurities. Then it passes to the lower end of the valve box mounted on the instrument. Between the pressure gage and the filter is a small pedal, by means of which the player can modulate the flow of the compressed air by means of his foot.

The horn is mounted on a stand beside the instrument, and a flexible pipe coupling connects the valve box of the instrument with the horn. The valve mechanism support is so made that it can be attached to or detached from the instrument in a few moments.

At the concert previously mentioned, the possibilities of the invention were very strikingly evidenced. The tone of the instrument was appreciably fuller, richer, and stronger when the auxetophone was attached, the harmonics were clearer, and the high-pitched notes were more clearly defined than is possible without the attachment. In the fortissimo passages the tones had a solid, well-rounded ring of great volume, while in pianissimo the expression of the artist was well produced with a softness accompanied by distinct clearness of the tones.

COMPRESSOR DESIGNING—THE DISTRIBUTION OF THE LOAD

By Frank Richards.

The air compressor shown in Figs. 1 and 2 may be regarded as a standard machine for the special line of work for which it is adapted. There is that which is picturesque for the engineer as well as for the landscape gardner, and this is a picturesque and interesting machine, embodying a number of details of ingenious design which are well worth considering. The compressing of air is not in any case as simple an operation as the pumping of water, and when high pressures are required, involving, as in this case, multiple stage compression, the problem of equitably apportioning the work and the effect for each step of the operation, the providing for the easy flow and the efficient cooling of the air between the stages, the reduction of machine friction to a minimum, the providing for the proper lubricating of all the working parts, the arranging of all for ready accessibility when wear or accident makes it necessary, constitute in all an intricate problem, the solution of which is well worth looking into. Nothing, of course, is final, and everything achieved is a challenge to surpass it, so that doubtless later there may be a better machine than this, or than any we now know of, and we must note its points of excellence while we may.

This is a three-stage air compressor designed to work to 1,000 pounds gage pressure, with a free air capacity of about 50 cubic feet per minute. It is a power-driven machine, the type of power application being according to circumstances. As here shown it has a pulley for a belt drive, but it may also be driven by a chain, by gearing, a Pelton wheel on an extension of the shaft, or by a direct-connected electric motor.

The dimensions of the cylinders are 8-, 5- and 2⅜-inch diameter, respectively, by 8-inch stroke, and the normal speed is 150 revolutions per minute, giving a piston speed of

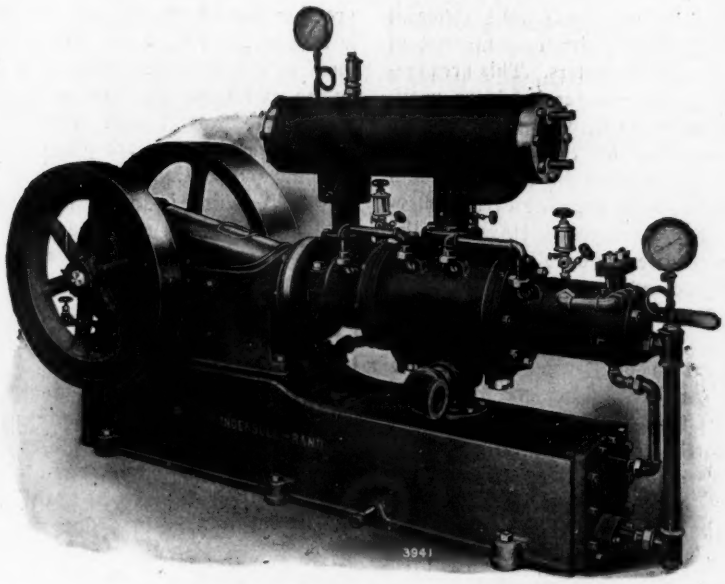


FIG. 1. THREE-STAGE AIR COMPRESSOR, TO COMPRESS TO 1000 POUNDS PER SQUARE INCH.

200 feet. The low-pressure, or intake, cylinder is double-acting and the other two are single-acting. The three cylinders are in a straight axial line, one piston-rod extending from the cross head through all the pistons. The low-pressure cylinder is between the other two, the intermediate cylinder being in front, or toward the crank, and the high-pressure cylinder at the back. The pistons of the intermediate and of the high-pressure cylinder are, in fact, plungers on each side of the low-pressure piston. The working area of the low-pressure piston on each side is, therefore, only that portion of the piston which surrounds the

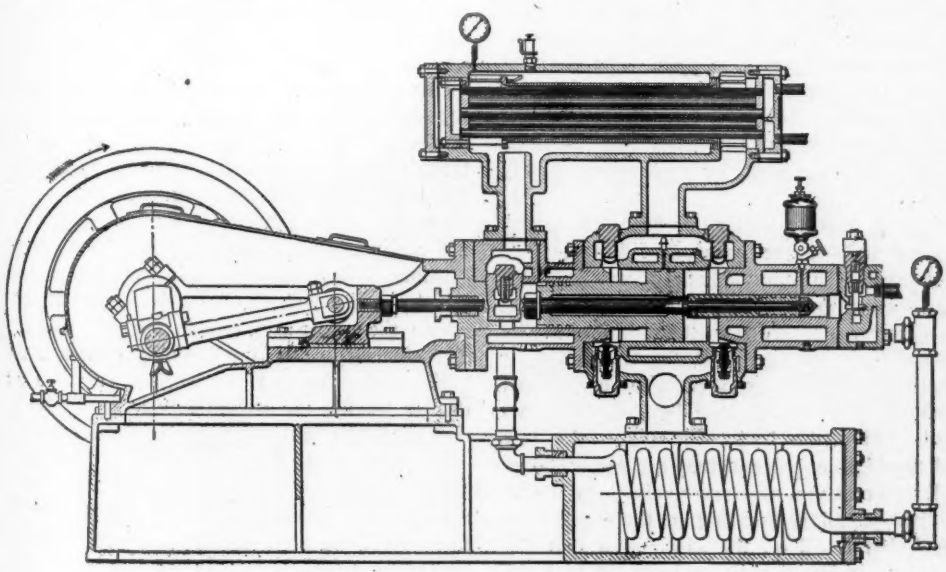


FIG. 2. VERTICAL SECTION OF THREE-STAGE COMPRESSOR.

plungers, and these areas are quite different on the two sides of the piston on account of the different plunger diameters. This arrangement gets rid of all cylinder heads or partitions and stuffing-boxes between the cylinders. The only stuffing-box for the entire machine is that in the head next to the cross head and opposed to the working pressure of the intermediate cylinder. The piston rings are the only packings required besides this one stuffing-box. The packing rings for the low-pressure and the intermediate pistons are sprung into grooves turned in the solid metal. In the high-pressure piston or plunger the grooves are not turned in the solid but are formed by removable sections which fit the piston-rod and also the cylinder bore, and which are cut away at the outer corner to form the grooves for the rings. When the main portion of this piston is in place in the cylinder, a packing ring is slipped in to fit against it; one of the movable sections of the piston is then slipped in against this, then another ring, then another piston section with a washer and nut outside, which secures all. The middle or low-pressure piston has a taper fit on the rod, and is secured by a nut outside the intermediate plunger, which thus locates it precisely and holds it securely.

The actual working clearances of one of these compressors, as determined by the inspector, were: for the low-pressure cylinder, 3/32 inch and 3/32 inch; intermediate cylinder, ⅛ inch; high pressure, ⅛ inch. The distribution of the pressures and the apportionment of the work of compression throughout the cycle of operations of this compressor are such as to make the work for each stroke nearly the same.

On the forward stroke, or with the pistons moving toward the crank, the low-pressure piston and the intermediate piston are both compressing to their respective pressures, and the receiver pressure against the high-pressure plunger is assisting; that is, its thrust at practically constant pressure is to be deducted from the total work done by the other two pistons. On the backward stroke, the low and the high-pressure pistons are compressing, and the receiver pressure against the intermediate piston is assisting in the work. By calculation based on the assumption that the compression is adiabatic, it is found that the horse-power required for the forward compression stroke of the low-pressure cylinder is 2.79, and for the same stroke of the intermediate cylinder, 8.52 H.P. The total horse-power resistance for the forward stroke is $8.52 + 2.79 = 11.31$ H.P. The intake pressure against the high-pressure plunger which is approximately constant, is sufficient to develop 3.13 H.P. which is to be deducted from the working horse-power of the other two cylinders giving us as the net horse-power for the forward stroke $11.31—3.13 = 8.18$ H.P. For the back stroke of the low-pressure piston the horse-power resistance equals 4.17 H.P., which is, of course, greater than for the forward stroke, because of the increased piston area. The resistance for the working stroke of the high-pressure cylinder equals 8.93 H.P., giving a total for both the low and high-pressure cylinders of $4.17 + 8.93 = 13.10$ H. P. From this it is necessary to deduct the power due to the intake pressure against the intermediate piston, which is found to be 3.13 H.P. The net power for the back stroke then will be $13.10 — 3.13 = 9.97$ H. P.

While the work of the two strokes is so nearly equal, that of the back stroke is the larger, which is as it should be, as this occurs on the thrust of the connecting-rod instead of on the pull. A sufficient reduction of the terminal delivery pressure would equalize the work for the alternate strokes.

As before stated, adiabatic compression is assumed in each cylinder, with efficient intercooling between the stages. The cylinders are all very completely water jacketed, so that the temperatures of the working surfaces are kept down, and satisfactory lubrication is maintained, but there is little cooling effect upon the body of air in the cylinders during the operation of compression. The circulation of the cooling water is accomplished by a single continuous flow through both intercoolers and all the water-jackets, there being no places where the water can remain without change. The efficiency of the intercooling is sufficiently indicated by the fact that the temperature of the air leaving the second intercooler and entering the last compressing cylinder was found upon a prolonged test to be the same as that of the initial intake or 70 degrees, and the temperature of the air as finally delivered, there being no after cooler, was 188 degrees. The final temperature for perfect adiabatic, single stage compression to 1,000 pounds would

be above 1,250 degrees, which would be prohibitive in practice.

In a test which was made of one of these machines, in which the number of strokes of the compressor required to fill a receiver of known capacity was ascertained, the volumetric efficiency of the compressor, or the ratio of the volume actually delivered to the total piston displacement of the low pressure cylinder, was determined to be 0.927.

This compressor considered in detail will be found to be an extremely simple one when the complication of function is allowed for. The main frame combines in itself all the particulars upon which perfect and maintained alignment depends. The first cylinder has a true seat against the frame and the other cylinders successively locate themselves by their seating, all the joints being scraped and the faces going together without packing. Every valve is independently accessible by the removal of its cap. Taking off the high-pressure cylinder (which is no more work than the removal of a cylinder head) makes all the pistons easily removable, and gives complete access to all the cylinder interiors.—*Machinery.*

CHARACTERISTICS OF CENTRIFUGAL AIR COMPRESSORS OR BLOWERS

The positive-pressure blower operates at constant volume and variable pressure, when the speed is held constant. That is, with every stroke of a reciprocating compressor or every revolution of the cycloidal type, a certain definite volume of air is taken into the compressor and discharged, the pressure of the air depending on the size of the orifice through which it is forced. Positive-pressure blowers are usually equipped with safety valves to prevent excessive pressure rise when delivering small quantities, and this leads to waste of power when operating at light loads.

The centrifugal compressor requires no safety valve and is thus much more efficient at light loads than the positive-pressure machine. The main characteristic of a centrifugal compressor is just the reverse of what it is in the positive-pressure blower. The pressure is nearly constant at constant speed, while the volume can be varied through a wide limit. The accompanying curve shows how the pressure varies in a centrifugal compressor from no-load quantity to load and a half.

By automatically varying the speed of a positive-pressure blower it can be made to work as a constant-pressure machine through a limited range, while by varying the speed of a centrifugal compressor it can be made to work as a constant-volume machine through a limited range.

In the centrifugal compressor this change of speed is obtained automatically by having a floating air governor attached to the inlet pipe of the compressor. This governor consists of a sheet-iron cone inside of which is a circular disk supported by the current of inflowing air. The height at which this disk floats depends on the quantity of air flowing. The disk is connected by levers, with the speed-controlling device of the driver, so as to change the speed with any change in the quantity of air flowing, and thus hold the quantity constant at the volume at which the air governor is set to operate.

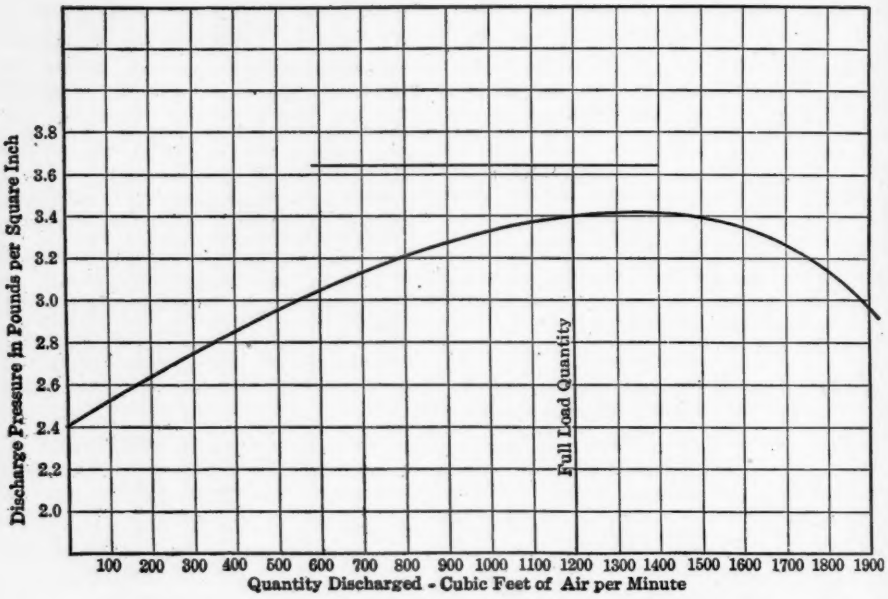
When starting a centrifugal compressor the blast gate should be closed until the machine has been brought up to speed and then it should be gradually opened. All openings closed gives light load on this type of compressor. This is the hardest thing about the machine for operating engineers to grasp, as it is directly opposed to positive-pressure-blower practice. The machine should never be run with the piping wide open to the air. Under these conditions it will deliver several times the full-load volume and since the pressure does not drop off a great deal at heavy overloads, as can be seen from the curve, the driver will be heavily overloaded, and if the compressor is motor-driven, the motor armature will be very likely to be burned out. With a turbine-driven machine no particular damage would be done.

It might be well to state for the benefit of those not familiar with this type of compressor that, due to the high speed at which they run, they are always direct-connected to the driver and the drivers are either high-speed motors or steam turbines.

The one great fault with this type of compressor is the liability of the impeller wheel to vibrate. The inherent characteristic of the machine requires very high wheel speeds. A common practice is to run a 30-inch wheel at 4,000 revolutions per minute. This gives a peripheral velocity at the rim of 31,400 feet per minute. While this is not a high value for turbine practice, it is for wheels con-

structed as are impeller wheels, and it requires the most careful balancing of the wheels to prevent excessive vibration at this speed. Excessive vibration may cause the impeller blades to break off, due to fatigue, and is almost certain to put the driver out of commission.

When two centrifugal compressors are used to pump into the same main header, a check valve should be placed between each machine and the header. If this is not done and it is attempted to run much under full-load quantity to the rising characteristic, and this in turn quantity will give a still higher pressure, due a larger quantity. This building-up process will continue until one machine is carrying nearly all the load. This tendency can be overcome by having the speed of the driver drop off as the load increases, and this change in speed can be obtained in turbine-driven machines by a simple adjustment of the governor for falling speed, and in direct-current motors by having them heavily compounded.—*Howard M. Nichols in Power and the Engineer.*



CHARACTERISTIC CURVE OF CENTRIFUGAL AIR COMPRESSOR

for both machines, one or the other of the machines will take all of the load and thus run at a heavy overload, while the other machine will be running light. The reason for this is that centrifugal compressors have a rising-pressure characteristic from no load up to nearly full load; that is to say, an increase in quantity of air delivered by the compressor gives an increase in pressure. This can be readily seen from an inspection of the curve. When two compressors are pumping into the same header there is a slight pulsation of pressure in each machine and as one compressor happens to reach momentarily a slightly higher pressure than the other, the slight increase in pressure will increase the quantity slightly on this machine, and the increased

DYNALITE AND SAFETY

Unless both heat and pressure combined are used on dynalite it will not explode. There is one case on record where a cartridge had been placed in frozen ore. One of the workmen, not knowing that the cartridge had been placed there, ran a red hot iron in the hole for the purpose of making it deeper. The iron ignited the dynalite and it burned up in the hole but did not explode. A party was loading a large blast with dynalite and had it nearly completed, when one of the men knocked a piece of flint rock into the hole, unknown to the manager, who was himself in charge of the blast. The workman took a steel drill to break the stone. He struck a spark, ignited the dynalite and, while it was burning, threw a

pail of water in the hole. All ran for their lives but no explosion followed, although there were forty pounds of dynalite in the blast.

The claims made by F. H. Briggs, the vice-president and general manager of the American Dynalite Co., regarding dynalite have passed from the realm of uncertainty to an everyday matter-of-fact certainty, proved by the accidents, mishaps and careless handling of dynalite during the past three years. Mr. Briggs has a most direct way of convincing people that his claims regarding dynalite are absolutely within the limits of truth. For instance, he takes a visitor through the mills, he shows him all there is to be seen there. Then he does some things which makes the visitor's knees tremble and his heart beat faster. He takes a loaded tube of dynalite, lights it with a match and holds it aloft like a Roman candle and, while burning brightly, hurls it against a tree. "You see," he says, "it doesn't explode." He inserts a fulminating mercury cap into the loaded tube, attaches a fuse, places another cartridge six inches distant, lights the fuse, retires with his visitor to a safe distance and watches results. A loud detonation, an upheaval of rock and dirt, the cartridge placed beside the one exploded is hurled 50 feet or more from the spot, but the concussion and the shock have left it whole. He demonstrates that it is a nonsympathetic explosive, by pouring a string of dynalite on a rock, taking a hammer and striking it. Only the dynalite grains directly under the blow of the hammer explode, making a noise like a percussion cap. The dynalite grains near those exploded are not disturbed. People using explosives are beginning to realize that dynalite is not dangerous, and wherever prejudice existed it is giving way to a better knowledge of this high and practically safe explosive.—*Rock Products.*

LIQUID AIR OR CARBON DIOXIDE FOR SKIN DISEASES

An American physician tried liquid air and carbon dioxide and obtained more or less success in cases of tuberculous abscesses, moles, pimples, and superficial cancer of the skin. Cotton wool, wound tightly on the end of a rod, is dipped into the double-walled glass flask of liquid air and then pressed lightly on the affected part of the skin. The skin freezes and becomes inflamed and in from 10 to 20 days the morbid growth sloughs off.

But liquid air is expensive and it also acts too energetically. An equaly efficient, but cheaper and more manageable agent is carbon dioxide, which was first employed for this purpose by Pusey. From the steel cylinder which contains liquefied carbon dioxide, the vapor is allowed to escape into a glass tube. Here it condenses into snow, which is compressed by a piston into a hard mass. This can be trimmed to the size and shape of the morbid growth to which it is to be applied, and thus the freezing of the surrounding healthy skin can be avoided.

The temperature of carbon dioxide snow is —130 deg. F., while that of liquid air is about —290 deg. F. The snow is cold enough, however, to freeze the skin into a hard, white mass in a few minutes. Too long an application may cause necrosis, or death, of the underlying tissues. The skin subsequently becomes slightly inflamed and a blister, similar to that caused by a burn, is produced. In general, freezing and burning produce similar effects on the skin. In two or three weeks the part that has been frozen falls off as a scab, revealing skin of quite normal appearance or marked by a slight scar. The application of this remedy is not attended with great pain. In the treatment of facial blemishes especial care must be taken not to freeze the skin too deeply. The field of application of carbon dioxide snow is extensive. Hitherto good results have been obtained chiefly in cases of lupus, but small tumors, callosities, moles, pimples, etc., also have been treated with success.—*Dr Bergrath in Die Umschau.*

MOISTURE CONTAINED IN THE AIR

By N. A. Carle.

The amount of moisture which can be held by a given quantity of air increases with the temperature and decreases with the pressure. The air is said to be saturated with moisture when it contains all the moitsure which it can hold at that temperature and pressure without condensation.

The moisture in the air is known as humidity and is measured on an arbitrary decimal scale, of which 100 is the saturation point of the air, at which it will hold no more water vapor, and 0 is the point at which the air contains no moisture.

The degree of saturation of the air is ex-

pressed by the ratio of the moisture actually present in the air to that which it would contain if it were saturated.

When the temperature of air containing moisture is falling, a point will be reached at which the air is saturated with moisture for that temperature and a further lowering of the temperature will result in a condensation of some of the moisture. The temperature at which this occurs is called the dew point of the air.

Air is never perfectly saturated, not even when it is raining; neither is it ever perfectly dry. Relative humidity is not a proper measure of the moisture contained in the air. At a low temperature even a high relative humidity represents a very small amount of moisture actually present in the air, while a low relative humidity at a high temperature represents a great deal.

For different saturation temperatures, the weight in grains of water vapor contained in a cubic foot of air is as follows:

Temperature of Saturation; Fahrenheit Degrees.	Weight of Moisture in a Cubic Foot of Air; Grains.
0	0.56
10	0.87
20	1.32
30	1.96
40	2.85
50	4.08
60	5.74
70	7.98
80	10.93
90	14.79
100	19.77

It is not the intention of the writer to discuss the methods of measuring relative humidity, except to say that two kinds of instruments are used for this purpose, "hygrometers" and "psychrometers." The hygrometer depends on the expansion and contraction of some substance in the presence of moisture in the air, in proportion to the amount of moisture present. A psychrometer consists of two thermometers; the bulb of one being covered with muslin so as to retain a film of water surrounding it. The evaporation of water from the bulb incased in muslin will cool it to an extent depending upon the amount of moisture present in the air. The relative humidity of the air is calculated by means of tables from the temperature of the dry bulb and the difference of temperature between the readings of the two thermometers.

The engineer is concerned with the question of humidity in cold-storage work, refrigeration and the ventilation of buildings. Data are usually available regarding the temperature of the air and its humidity or degree of saturation. What the engineer wants to know is the actual amount of moisture present in the air which is to be handled. The chart on the opposite page is designed to show the weight of water in ounces contained in 1000 cubic feet of air, when the temperature and relative humidity are known.

EXAMPLES.

(1) If the temperature of the air is 70 degrees Fahrenheit and the humidity is 75, how many ounces of water are contained in each 1000 cubic feet of air?

Starting with 70 degrees Fahrenheit, read up to the line showing the amount of water contained in the air at saturation and then across to 75 per cent. humidity and down to 13.7 ounces of water per 1000 cubic feet of air.

(2) If the temperature of the air is 90 degrees Fahrenheit and the humidity is 85, how much water is carried by the air per 1000 cubic feet?

Starting with 90 degrees Fahrenheit, read up to the line showing the amount of water contained in the air at saturation and then across to 85 per cent. humidity and down to 28.7 ounces of water per 1000 cubic feet of air.—*Power and the Engineer.*

The ultra scientists are telling us that a firefly converts the hydrocarbon of its food into light with an efficiency of 40 per cent., while rarely is as much as 10 per cent. of the energy of coal transformed into electrical energy.

The various telegraph and telephone companies in the United States had in use in 1907, 15,072,220 miles of wire. Of this, 12,999,369 miles were controlled by telephone companies. Of this again, 5,092,223 miles were in open aerial lines; 2,917,114 in aerial cables; 4,969,302 underground and 20,730 in submarine lines.

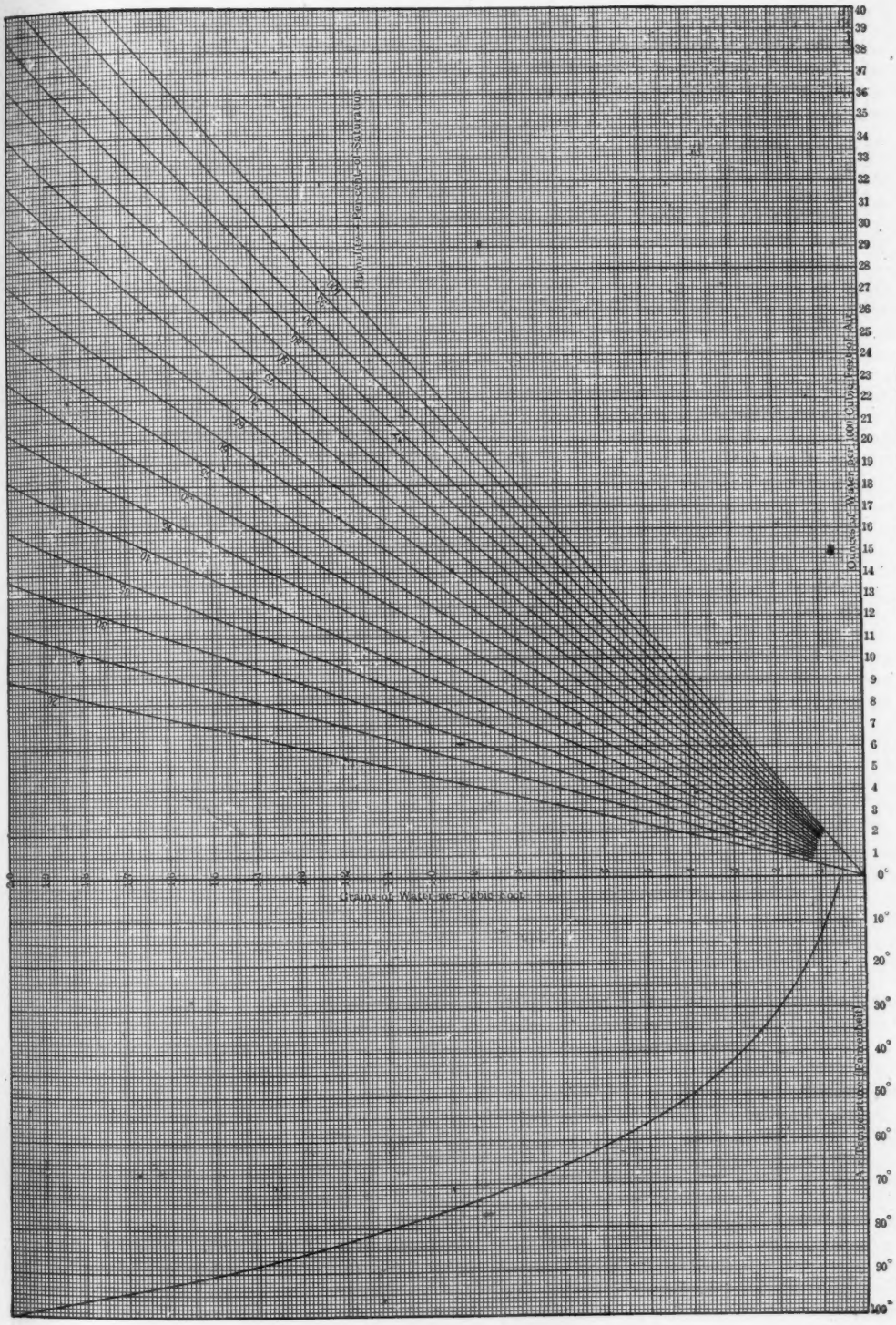

Percentage of Saturation
Grains of Water per Cubic Foot
Grains of Water per 1000 Cubic Feet of Air
Temperature (Fahrenheit)
Temperature (Centigrade)

CHART FOR DETERMINING THE AMOUNT OF MOISTURE CONTAINED IN THE ATMOSPHERE.

A SUCTION DREDGE RECORD

Along the Clyde river, near the junction of Wayne, Seneca and Cayuga county lines lies an extensive tract of comparatively low, flat land, where the rank cattails nod their russet pompons and mosquitoes grow as big as humming birds. This has long borne the name of the Montezuma marshes. Through this locality the portion of the Barge canal project known as Contract No. 46 has been laid out, and the Kinser Construction Company has undertaken its completion. Quietly and unostentatiously a suction dredge of ordinary type, with timbered, A-shaped, main frame, bearing the 20-inch suction tube and cutter forward, centrifugal pump amidships, and attended by the usual line of pontoon discharge pipes, was built during the present season, in the vicinity and using local facilities. This dredge, the *Montezuma,* was recently placed in commission, and its performance since has certainly established a new monthly record for hydraulic dredges on Barge canal construction, if not indeed a world's record, for dredges of its size and type. Its output for the month of August has been already noted as 251,741 cubic yards, but in the month of September it nearly doubled this record, removing the enormous total of 454,706 cubic yards of material from the prism of the canal and depositing it in adjacent spoil banks. Of course the peculiar nature of the material that this namesake of the imperial Aztec has encountered is largely responsible for the voracious appetite which it has developed. The conditions here are almost ideal for this type of excavator. No vegetable growth clogs its pipes and no rock or stone occurs to hinder the swift revolving cutter-blades.—*Barge Canal Bulletin.*

FUSION WELDING WITH LIQUEFIED LIGHTING GAS

By Alfred Gradenwitz.

The local heating of metals to melting temperature is known to require a point flame of very high temperature, which has so far been mostly produced by oxy-hydrogen torches, i.e., torches to which hydrogen is supplied as fuel, and pure oxygen in the place of combustion air. The flame produced with this torch possesses a temperature susceptible of melting most metals. In fact, the remarkable intensity of oxy-hydrogen flames, as compared with those of a mixture of air and hydrogen, is accounted for by the fact that the oxygen of air contains nitrogen to the extent of 79 per cent. which takes no active part in the chemical process of combustion, while absorbing a large amount of the combustion heat, and thus cooling the flame.

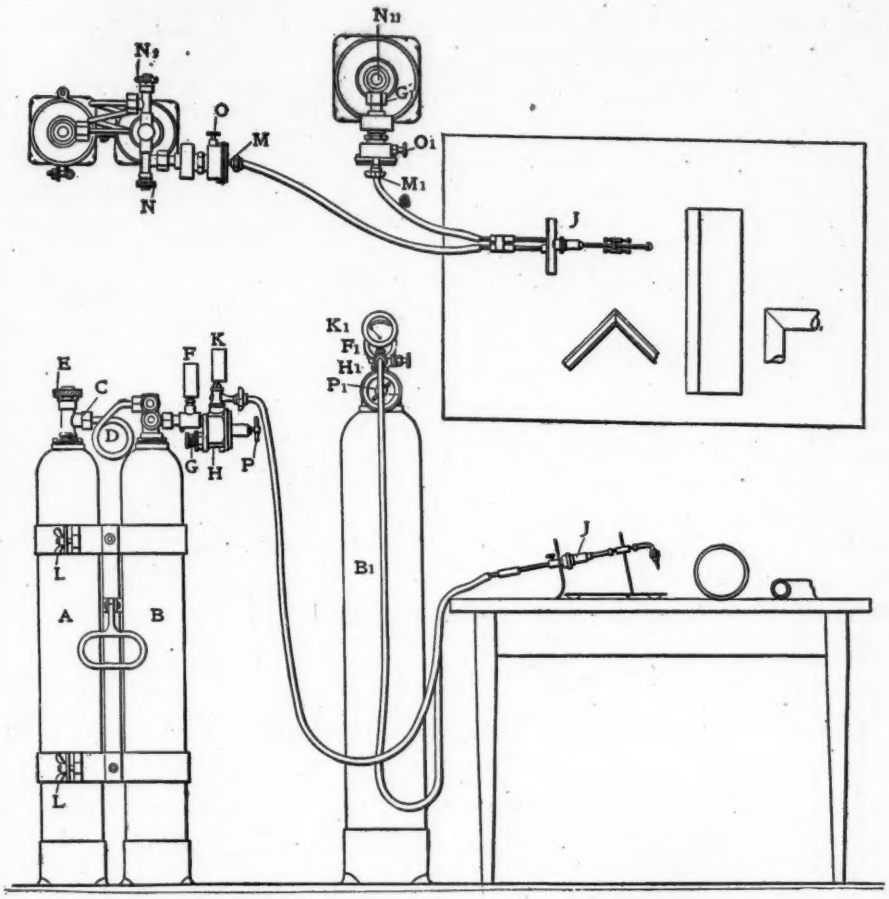
Oxy-hydrogen torches have been used of late years with excellent results in the most varied branches of industry, for fusion welding, the metal being melted locally and allowed to flow together at the seams, without the use of any auxiliary substance or process.

Experience has shown that all gases containing, as elementary components, hydrogen and carbon are adaptable for fusion welding, and the question as to which gaseous fuel is most convenient, mainly depends on the cost of equal amounts of heat units available in the gas as well as on the convenience of the apparatus used. The original oxy-hydrogen process has been found the most convenient and reliable welding method, both gases being sold, in the compressed state, in bottles to which reduction valves for controlling the pressure are readily fitted.

Owing, however, to the considerable specific volume of hydrogen, and the corresponding expensiveness of its transport, this gas has been partly replaced by acetylene.

An important advance has been recently made in the gas industry by Mr. Blau's invention of a process for generating liquid lighting gas. This material, under atmospheric pressure, is gaseous like air, but becomes liquid as soon as its pressure undergoes a moderate increase. In this condition it is extremely suitable for transportation to any distance, like other liquid fuels, such as oil, alcohol, etc.

Blau gas is as transparent and clear as water and possesses, of all commercial gases, the highest lighting and heating values. Similarly to oil gases, it is a combustible material obtained from mineral oils by distillation in red-hot retorts, and comprises the same chemical elements and compounds (hydrogen, methane, saturated and nonsaturated hydrocarbons) as coal gas, though in considerably different percentages. However, this gas is absolutely free from carbon monoxide and accordingly possesses the advantage of not being poisonous. During its solidification, it contracts to about 1/400 of its initial volume



BLAU LIQUID GAS WELDING APPARATUS.

and therefore can be introduced into readily transported steel bottles of different sizes.

This liquid gas has been found to be a fuel which, while being as convenient as compressed hydrogen, is even cheaper in operation than acetylene, for the fusion welding of metals. A further advantage of Blau gas-oxygen welding is the fact that the apparatus (which even in the case of large outputs is readily transported) is free from any water, and accordingly is exposed to no destructive chemical influences such as rusting. On the other hand, the apparatus is as cheap as any, and as the gas is sold in a purified condition, it does not require any cleansing or discharging of refuse, such as lime, slime, etc.

In Fig. 1 is shown a Blau gas-oxygen welding apparatus. This consists of the following parts:

(1) A transportable gas bottle *A* connected to the steel bottle *B* serving as gas reservoir, by the copper tube *D* and intermediary locking valve *N2*.

(2) The reduction valve *H* connected to the locking valve *N* with the pressure gage *F* for determining the gas pressure in the bottle *B*, and the gage *K*, on which is read the gas pressure, controlled by the spindle *P* of the safety valve *G*.

(3) The reduction valve *H*, the jet controller *F*, the pressure gage *K*, and the safety valve *G*, for oxygen.

(4) A Blau gas conduit, with nut *M* for the gas.

(5) A Blau gas conduit with nut *M1* for oxygen.

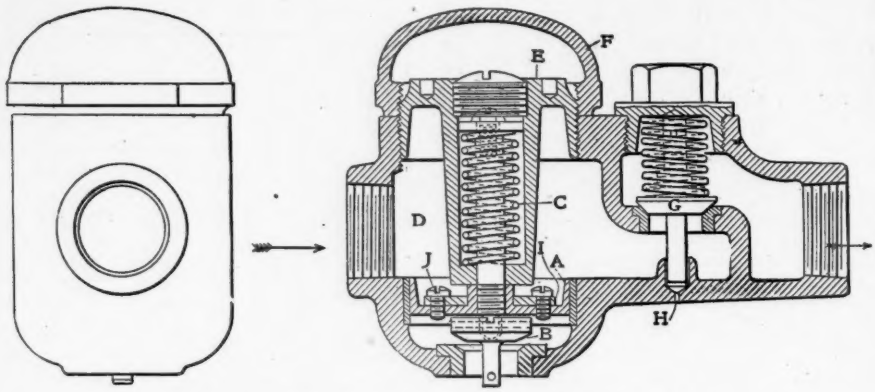
(6) The welding torch *J* with exchangeable mouth-pieces.

AUTOMATIC UNLOADING DEVICE FOR BELT OR MOTOR-DRIVEN AIR COMPRESSOR

By S. Rice.

In the accompanying sectional sketch is shown an ingenious unloading device for motor-driven air compressors, which device consists primarily of a piston having a bypass, a valve which is closed when the piston reaches its extreme motion against a spring, and a check valve. It is placed in the discharge pipe between the compressor and the reservoir and provides an opening from the discharge pipe to the atmosphere until the motor reaches a predetermined speed for which the device is set.

When the driving power is first applied, the pistons of the compressor will move slowly and will gradually increase their speed as the motor revolutions increase, thus raising the air output of the compressor. The air first passes



UNLOADING DEVICE FOR POWER DRIVEN COMPRESSOR.

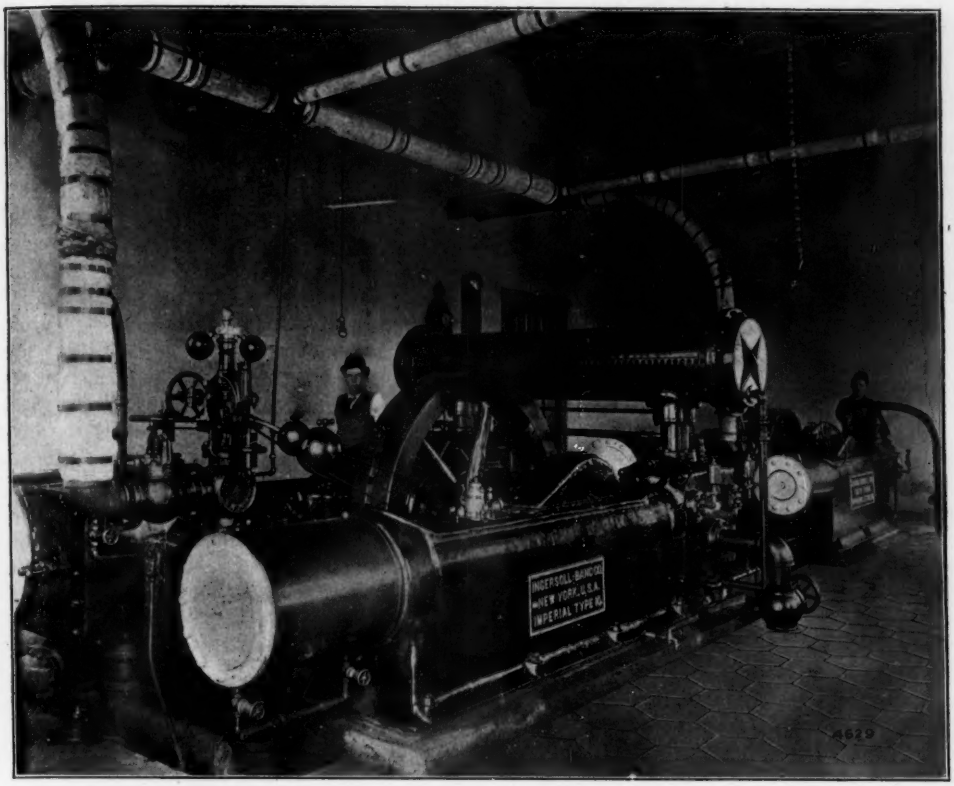
piston *A* and to atmosphere through valve *B*, which is held open by a spring *C*. As the volume of air becomes greater, the bypass in the piston can no longer take care of the increase as the motor comes up to somewhere near full speed and the pressure rises in chamber *D*. When this pressure reaches a point sufficient to compress the piston *A* and seat the valve, the check valve *G* immediately begins to work and the leakage of air to the atmosphere is cut off by the seating of valve *B*.

The device can be so adjusted that the piston will seat valve *B* when the motor has into the chamber *D*, through the bypass in the reached a limit of approximately three-fourths full speed. When the motor is stopped, the check valve *G* is seated and pressure in chamber *D* is gradually reduced by the leakage of air to the atmosphere through the small opening *H*. When the pressure is slightly reduced in chamber *D*, the piston *A* and valve *B* are drawn in through the action of the spring *C*, thus unseating the valve *B*, and the motor is ready to start again.

The bypass consists of two good-sized holes drilled in the piston *A*, and two corresponding holes in the plate *I*, which may or may not match, according to the position of plate *I*, and which may be adjusted to give any size of opening desired by means of screws *J*. Further adjustment may also be made by removing the cap *F* and turning the nut *E* holding the spring and locating the inner position of the piston, thus increasing or diminishing the amount of travel that the piston has to make in order to seat the valve *B*.—*Power and the Engineer.*

ONE AIR LIFT SUPPLIES A CITY

The city of Thomasville, close to the southern line of the state of Georgia, has a population of 8,000 and its entire water supply comes from a single well operated by the air-lift. The half-tone shows the air compressor in use, an Ingersoll Rand Imperial, with compound steam and compound air cylinders, the compressor in the rear being an earlier installation by the same builders and now kept as a reserve. The well was bored to a depth of 565 feet, and as the water rises to 185 feet from the surface an ample pipe submergence is provided for.



COMPRESSOR FOR AIR LIFT AT THOMASVILLE, GA.

This plant not only supplies all the water for daily use but provides also for fire service, maintains twenty public fountains and furnishes a railroad with 1,500,000 gallons a month. For fire service there is a standpipe and special piston pumps which give a pressure that dispenses with use of fire engines.

It is found to cost in fuel one cent a thousand gallons for each 100 feet of lift, the total lift in this case being 300 ft. All water supplied is metered and it is sold at 15 cents per 1,000 gallons, net, with a minimum charge of 25 cents per month.

Both this water plant and an electric lighting plant are owned by the city and have been in operation a sufficient length of time to give assured results. The service is all that could be desired and there is always a safe cash balance in favor of the city, although of course no money making is desired or would be permitted by the citizens.

THE MEASUREMENT OF HUMIDITY

By Samuel K. Patteson.

The moisture in the atmosphere affects unfavorably almost every engineering device in which the atmosphere enters as a factor in its operation or design. The gas engine is affected very greatly in its action by the presence of moisture in variable amounts in the atmosphere, and in special developments of this type, the effect is often sufficient to temporarily swamp the engine. The same effect is also present in small marine engines with even more pronounced significance, and its effect is also present in all internal combustion motor installations. Again, cooling towers depend for their efficient action almost entirely upon the amount of moisture present in the atmosphere, and under some conditions of great humidity their effective action is often almost completely stopped. The presence of moisture in the blast in iron furnace operation had long been

known to be the chief variable quantity in its effect on the character and uniformity of the product, and only recently have satisfactory devices been constructed for the efficient elimination of the moisture in such cases.

In air compression as well the presence of moisture in the air is well understood, and its limiting effect on efficiency can be greatly diminished by proper study and prevention of this phenomenon. These developments represent a comparatively few of the processes in which the presence of moisture in the air affects the efficiency of the operation, but they are essentially the more important classes and give a fair idea of the importance of this factor in engineering progress.

The problem itself from a physical or engineering viewpoint is essentially a single development of the broader one involved in the mixture of two or more vapors or gases, and the laws governing their relative proportions under variable conditions of temperature and pressure are fairly well understood, although this development is one in physical science which is undergoing rapid progress to-day. The basic conditions or laws which govern all these relations are primarily the fundamental laws of gases and vapors. Thus Boyle's law holds for a gas independent of the presence of some other gas or vapor. In an equal sense Charles' law, showing relation between pressure, volume and temperature of the gas, is equally true independent of the presence or intimate mixture of some other gas or vapor in the one under measurement. Dalton's law is the particular one that applies in these conditions, and, stated briefly, it consists in the fact that all gases or vapors exist in conjuction with each other according to exactly the same laws that would hold if the others were not present.

Water vapor occupies space filled with air in precisely the manner that water vapor would tend to occupy space or vacuum if the air were not present. The ordinary atmospheric pressure of 14.7 pounds to the square inch is, therefore, according to this law, a combination pressure, due to the pressure of the atmosphere alone and the pressure of the water vapor present. The water vapor exists in quantities in this air dependent upon the temperature alone, and varies with it, and also with conditions which affect the degree of saturation. Thus, according to Dalton's law, if a cubic foot of dry air is taken, it will exert a definite pressure of, say, 14 pounds to the square inch. If a drop or two of water is injected into this, under normal conditions, the pressure will immediately rise from 1-2 to 1 pound to the square inch, and the pressure of the mixture will then be, approximately, 15 pounds, as recorded on an absolute pressure gauge. If a drop or two of alcohol is then injected into the mixture, the vapour of this liquid will tend to occupy the space in precisely the manner the water vapor has done and just as though the others were not present. Under these conditions the pressure will rise again from ¼ to ¾ of a pound, or a variable amount dependent upon the nature of the vapor and the temperature.

As far as known, pressure can be increased indefinitely by this process by simply increasing the number of volatile liquids which are injected into a given space, and such pressure could undoubtedly be used for the production of work. However, the extent to which Dalton's law is true under such extreme conditions is problematical, and this development represents another phase in physical science which is undergoing investigation at the present time. The simple problem of the mixture of water vapor with the atmosphere is, as has been said, fairly well understood and represents to-day the chief development in which the practical aspect has been forced to the front.

The water vapor in the atmosphere can be readily removed by any chemical dryer. Thus if a given quantity of air is enclosed in a vessel containing lime or sulphuric acid, and the vessel shaken up, if desired, for more complete effect, all the moisture will be removed from the air and the pressure of the latter will fall. If the chemical agent, lime, calcium chloride, sulphuric acid or any well known dehydrators are weighed before and after this treatment, the moisture content for this quantity of air is absolutely determined, and a device or mechanism for the performance of this experiment readily and accurately is known as a chemical hygrometer.

While the actual quantity of water in air is of very great importance under many operative conditions, its relation to another value, namely, the saturation content, is often of much greater significance. In general, a saturated vapor can be defined as a vapor in which the quantity of material held is at its maximum. Any increase in the material present in the space either due to actual introduction,

or to an increase in density caused by pressure, will cause a deposition or condensation of a portion of this vapor into its liquid form. It is analogous to what is known as the dew-point in atmospheric conditions, and at this latter temperature the ordinary air contains saturated water vapor. Any variation, as stated, or a diminution in temperature results in a condensation or diminution in the weight of the vapor present. Thus one condition for the presence of a saturated vapor is the presence of a liquid surface of the same material immediately contiguous both in regard to time and place. Thus the water vapor in the air is saturated or not saturated, dependent soley upon the presence of large quantities of water in the vicinity or the close time relationship of the air in its contact with this surface.

When a gas or vapor is heated, it tends to expand and occupy a larger space. Hence a saturated vapor gradually becomes in an unsaturated condition with rise in temperature, and is capable of absorbing, on contact with its own liquid, an amount of the material in the form of vapor sufficient to render it saturated. The amount of saturated vapor which the air can, therefore, hold at any given temperature is readily determined by a reference to the steam tables for this temperature, and this steam pressure in practice is represented by a certain definite fraction of what is known as ordinary atmospheric pressure. The relation of the amount of water vapor present in the air to the amount that the air could contain if the steam or vapor existed in a saturated state, is known as the hygrometric state or percentage of humidity, and is of very great importance in engineering practice, especially in cooling tower operation and allied phenomena, since it represents the capabilities of the air in regard to its absorptive power for moisture present in surrounding bodies, and hence its cooling effect in cooling towers and its drying capabilities as a dehydrator.

While the ratio of the amount of moisture present in any definite amount of air to the amount that it should contain at this temperature, as determined according to the steam tables, is known, as has been said, as the hygrometric state, yet this ratio is numerically equal to a number of other different ratios relating to the same phenomenon. Hence this state is often defined in a number of other ways which often enable it to be measured much more readily and satisfactorily than can be done by this procedure. Thus the pressure of a saturated vapor is a function of the temperature only, and is independent of the volume. Hence the amount of material present in a saturated vapor is proportional to its pressure. In the same way the pressure of an unsaturated vapor is proportional to the amount of material present, if the temperature and volume are kept constant. Hence the unsaturated pressure of a vapor is proportional to the amount present, and the hygrometric state reduces to a ratio of the pressures of the unsaturated and saturated vapors which are present or can exist under given indentical conditions.

This ratio of the pressures is equal numerically to the ratio of the weights and is known as the relative humidity or the hygrometric state, and with some instruments, designed for this purpose, is much simpler in its determination than is possible by a direct determination of the weights, even though one has been determined and is obtainable from the steam tables. Again, since the pressure of a saturated vapor is directly proportional to its temperature, and somewhat analogous conditions hold for unsaturated vapors, the ratio can be reduced to temperature variations, and we have the hygrometric state or relative humidity of a given air content as a simple funtion of its temperature and the temperature of its dew point, namely, that temperature to which the air must be lowered in order that water shall be condensed or dew produced readily.

Nearly all hygrometers, other than the chemical one, utilize this last relationship for the determination of the moisture content and relative humidity. They consist essentially of two thermometer bulbs, one of which records the temperature under given conditions, and the other is surrounded by some cooling agent whose temperature it records at the time when dew is produced or moisture has become perceptible in this form in the immediate vicinity. Thus the wet-and-dry bulb hygrometer consists simply of two thermometers, one of which has its bulb surrounded with an ordinary cotton wick which has its end immersed in a tube of water. The capillary action keeps the wick moist, and the evaporation into the air produces the cooling effect which is at once perceptible in the reading of the thermometer.

The scale used with this device is a purely arbitrary one, determined through calibration with a chemical hygrometer or dew-point measuring device, but gives fairly satisfactory and accurate results of the relative humidity.

The actual dew-point hygrometer, so-called, consists of two thermometers, one for the registering of the atmospheric temperature and the other for the determination of the dew-point. This latter thermometer is surrounded by another bulb, into which ether or some other volatile liquid can be poured and rapidly evaporated by passing air through it by means of blowing or by the action of an ordinary water aspirator. This bulb containing the ether is partially covered by a polished metallic surface, and when the cooling effect produced by the evaporation of the ether has continued a sufficient time, this surface will become covered with moisture, due to the condensation of the water vapor present in the air, and the temperature at which this occurs is recorded by the thermometer, which gives the temperature of the boiling or evaporating ether. This device is much more satisfactory than any of the arbitrary calibrated ones.

The amount of water vapor present under ordinary conditions is comparatively small, being, approximately, 5.85 grains per cubic foot as an average for a five days' test at the installation of the refrigerating plant for the removal of moisture from the blast in iron furnace operation at the Isabella furnace of the Carnegie Steel Company at Aetna, Pa. This represents approximately normal values, which vary however, from one grain to as high as eight or more, and even considerably larger values represent fairly average conditions in the tropics. The eastern sea coast of the United States represents a much greater hygrometric average than is present in the Middle West, and this latter bears almost an equal ratio to Rocky Mountain conditions. In the installation mentioned, each grain of moisture content per cubic foot meant a water removal of 40 gallons per hour, so that the effect, in the aggregate, is by no means neglible.

In addition to its effect in blast-furnice operation and internal-combustion motors and air compression, its significance in cooling towers and their operation is equally pronounced. A cooling tower on a dry day may readily cool steam condenser water of 160 degrees to 200 degrees F., to values as low as 70 degrees or 80 degrees F., whereas on a moist, warm day the fall in temperature may not exceed one-half to one-third of this.

The temperature of the air is, in reality, a matter of minor significance, and a number of tests are under consideration by cooling-tower manufacturers, undertaken with a view to the actual introduction of heated air into the cooling tower for the purpose of increasing effect on account of the increased possibilities in absorption of water vapor under these conditions. The fact that mechanical refrigeration has been proved to be a most efficient device in the removal of the water present in the air, and the further fact that this mechanical refrigeration can often be produced by the utilization of exhaust steam, a commodity or by-product often wasted, represents a condition which permits of its development for this purpose with a comparatively high degree of efficiency. The situation is such that practically no engineer can afford to-day to be without this knowledge in regard to hygrometric conditions, and to have some conception of the effects of the presence of the moisture in the air upon any special process in which he is interested.—*Condensed from Cassier's Magazine.*

CONCLUSION OF CAISSON DISEASE DISCUSSION

Since the publication in our October issue, page 5431, of the discussion of the paper by Henry Japp upon Caisson Disease and its Prevention the conclusion of the discussion has come to hand, this being here reproduced, somewhat abridged, from the Proceedings of the American Society of Civil Engineers. It will be remembered that in Mr. Japp's paper he said that "Thus far, practically, no grandfatherly legislation hampers engineers in the United States," while in his conclusion of the discussion here given he speaks in commendation of a New York State law which had been enacted in the interim.

T. Kennard Thomson, M. Am. Soc. C. E.—The writer has read this valuable paper with much interest, and notes that the author does not refer to the old-fashioned remedy—the electric battery—probably because it is not nearly as reliable as recompression. The writer once cured himself of an attack of bends by electric shocks, after he had failed to get

any relief from recompression; and the next time the battery failed to cure him and recompression did—and so it goes. He has had the bends after being under an air pressure of 23 lb., and was not affected by a pressure of 35 lb. on the same job. The purity of the atmosphere and the physical condition of the man at that particular time have much to do with the case.

The writer, *having no ear drums*, has never had much trouble in keeping his ears from getting blocked, and, as a rule, he has been affected much less by the air pressure in vertical caissons than in tunnels; this he ascribes partly to the fact that the air in caissons is renewed more frequently than in tunnels and therefore is fresher, and partly to the increased time he was obliged to remain in the tunnels to get to the headings.

Under the Harlem River, when under comparatively light pressure, while sinking through the foul river bottom, his men have been much troubled by the bends, but have experienced very little inconvenience under much greater pressure while the caissons were sinking through the clean clay below the river-bed.

In an emergency, the writer has seen men work for 18 or 20 hours in pressures up to 25 lb. without any ill effects. He has gone in and out of the caissons repeatedly for 86 hours (without going to bed), under pressures up to 35 lb., without inconvenience—but would never be guilty of such hours again.

When he had the bends, the pain disappeared while he was in a perspiration induced by drinking hot coffee, only to return when he had cooled off. He then tried a very hot bath and felt well until he had dressed.

As stated by Mr. Japp, slow decompression is the best preventive known, and recompression is not always reliable. As the author also states, hot coffee should always be taken on coming out.

HENRY JAPP, M. AM. SOC. C. E.—The discussion, thus far, seems to indicate that the general opinion is that the cause of caisson disease is the presence of gas bubbles in the blood and tissues, the only one taking exception to this being Dr. Loomis, who states that bubbles have only been demonstrated under exceedingly high pressures—15 or 20 atmospheres.

The writer cannot agree to this as he has seen the results of three autopsies on men who have died on coming out of pressures between 30 and 35 lb. gauge, and in each case bubbles were plainly visible to the naked eye in the blood vessels; and he has read reports of many more, and in almost every case similar bubbles have been seen. In one case Drs. McWhorter and Erdman were able, at the autopsy, to collect and analyze the air which escaped from a large bubble in the heart. It may be thought that these bubbles are not present during the life of the subjects, but the writer has also seen what had every appearance of being little bubbles passing along in the blood vessels of the wrist of a member of the East River Tunnels staff about half an hour after he came out of the air pressure.

Dr. Loomis' extraordinary success, in having so few deaths as he mentions, is highly commendable, but there is no doubt that if a larger number of fatal cases had passed through his hands he would have made similar observations.

The fact that Dr. Leonard Hill has exhibited the formation of bubbles and the stoppage of the circulation in the web of a living frog by sudden decompression, and the disappearance of the bubbles and the resumption of the circulation by recompression, should of itself show

Gauge pressure, in pounds.	Time under pressure.	Interval between spells.	Uniform decompression, in minutes.
0-28.....	8 hours, less interval.....	30 consecutive minutes spent in the open air.....	18⅔
28-35.99....	2 spells of 3 hours each...	At least 1 hour.....	24
36-41.99....	2 spells of 2 hours each...	At least 2 hours.....	42
42-45.99....	2 spells of 1½ hours each.	At least 3 hours.....	46
46-49.99....	2 spells of 1 hour each....	4 hours.....	50

No employee shall be permitted to work in pressures exceeding 50 lb. per sq in. except in cases of emergency.

The decompression shall be at the rate of 3 lb. every 2 min., unless the pressure shall be over 36 lb., in which event the decompression shall be at the rate of 1 lb. per min.

TABLE 5.

that, although this was obtained by high pressures for the purpose of rapid demonstration to an audience, the same thing can readily occur with a lower pressure.

While Dr. Loomis does not accept the theory that bubbles of gas cause bends, he presents no alternative.

Dr. Haldane suggests that, as the conditions vary so widely in different kinds of work, it is undesirable to lay down by legislation or otherwise any hard-and-fast rules as to decompression, and in the paper the writer calls attention to the danger of legislation if it is not guided by the Profession. Since this paper was written, however, the New York State Legislature has enacted a law which limits everything. The hours of labor and the rates of decompression are according to Table 5.

This law is a great step in advance of anything attempted privately in the United States, and the Commissioner of Labor is to be congratulated, but if these rates are compared with the suggested Table 4 of the paper, it will be found that the new law proposes a greater degree of safety for the lower than for the higher pressures, and inasmuch as the law requires that the decompression shall be uniform, the final pressure in the blood on coming into the atmosphere will be much higher than would result from stage decompression. In order that this may be seen more clearly, the writer has calculated the pressure in the blood for the various pressures, decompressing uniformly as required by the law, and also by stage decompression, and gives the results in Table 6.

Tunnel pressure, in pounds (gauge).	Time worked, in hours.	Uniform decompression, in minutes.	Pressure in blood on emerging, in pounds.	Stage decompression, in minutes.	Pressure in blood on emerging, in pounds.
28	8	18⅔	25.70	14	25
36	3	24	30.25	36	25
41.99	2	42	31.25	37	25
45.99	1½	46	32.00	35	23
50	1	50	32.50	33	25

TABLE 6.

It will be noted that, whereas the stage decompression proposed fixes the pressure in the blood on emerging from the air-lock at a constant of 25 lbs. per sq. in., the uniform decompression periods required by the law give pressures in the blood on emerging varying from 25.70 up to 32.50 lb., such a result being obtained in the case of 50 lb. with 17 min. longer for uniform decompression than stage decompression, and when it is noted that, for a pressure as low as 9 lb. per sq. in., the law requires 2 min. for every 3 lb., or 6 min. for decompression, it will be seen how inconsistent are the requirements. In other words, the new law requires generally more time for uniform decompression than is needed for stage decompression, while giving less safety.

It is doubtful whether Dr. Keays is correct in stating that the body fluids are practically saturated at any given pressure in about 3 hours. Fig 4. (Compressed Air Mag. page 5404) shows that in 3 hours the slower saturated parts are only 81 per cent. saturated, but the writer is of the opinion that much could be done toward ascertaining the rate of saturation by further experiments.

With regard to Dr. Keays' remark on "delayed caisson disease" (that is, cases which occur many hours after decompression), and his deduction, from those which occurred after too rapid decompression, that the lengthening of the decompression to periods suggested by Dr. Haldane would not prevent all cases of illness, or even serious and fatal ones, this cannot be accepted as more than an expression of opinion, inasmuch as no cases had occurred in Dr. Hadlane's experience when his rules were adopted, and it is doubtful if any delayed cases would occur or would have occurred had Dr. Haldane's rules been adopted, as the sole object of slow-stage decompression is to prevent the formation of injurious bubbles.

Delayed caisson disease after too rapid decompression can be explained by the accumulation of gas in tissues, which, though strong enough to stand the pressure of the accumulated gas for some hours, ultimately break down under the strain. Liberated gas collected in pockets cannot very readily be absorbed again excepting by recompression.

Mr. Saunders' description of the effects of recompression and decompression in his own case, when he was paralyzed, is an excellent illustration of the bubble theory.

Dr. Erdman's idea of the lungs acting as an escape valve is very ingenious, and is quite in line with the general mechanical theory of caisson disease. An investigation on the lines of his suggestion would be very valuable.

Mr. Aims' reference to the effect of dissipation on the resistance of men to the effects of compressed air and to the effect of the general comfort of the men coming out of the air-lock is generally accepted as important, but with slow decompression the discomforts of fog and cold are not felt in air-locks, and therefore heating is not as important as in the case of more rapid decompression.

Dr. Loomis' suggestion that the weather changes play a very great part in the causation of disease is not borne out by observations made by the medical staff on the East River Tunnels.

Mr. T. Kennard Thomson's remarks are valuable, coming from a man with so much actual experience in air pressure, and his acceptance of slow decompression as being the best preventive known—coming as it does from an engineer, the bulk of whose experience has been in caissons with small air-locks, where slow decompression is not an easy matter—leads one to hope that, even under such disadvantages, practical men will ultimately arrange for a slow decompression.

The reason why recompression is not always reliable, as Mr. Thomson says, is that the bubbles having torn the tissues and done the damage, no amount of recompression which merely removes the bubbles will heal the torn tissue, but if recompression can be resorted to promptly, before any permanent injury is done, then relief will be obtained.

THE SMOKELESS BURNING OF COAL

At the experimental station of the United States Geological Survey at Pittsburg it is claimed that a workable solution of the problem of smokeless coal combustion has been found. The plant in that city of smoke is being operated absolutely without smoke, in spite of the fact that it is using coal considered refuse by the trade and costing only 88 cents per ton delivered at the station. The secret of the success lies in perfect and complete combustion before the gases strike the chilling surfaces of the boiler.

The statement is made in this connection that "in 50 per cent. of the industrial plants of the United States more than 10 per cent. of the coal bill can be saved each year by the smokeless burning of coal." The trouble has been to contrive practical arrangements that would make smoke consumption, or rather smoke avoidance, an actual economy to the man who pays the bills; "and until that is done," says the *N. Y. State Board of Health Bulletin* "the esthetic loss of a sunless, smoke laden atmosphere, the monetary loss in the deterioration in smoke begrimed commodities and the unquestionable physical loss in the deleterious effects of smoke upon the health seem fated to continue on unchanged.

ACIDS

Acid is a general term used in chemistry, and is applied to a group of compound substances possessing certain very distinct characteristics. All acids have one essential property, viz.: that of combining chemically with an alkali or base, forming a new compound, which has neither acid nor alkaline character. New bodies formed in that manner are called salts. Every acid is therefore capable of producing as many salts as there are basic substances to be neutralized, and this salt-forming power is the best definition of an acid substance. Most acids when applied to the tongue have a very sour taste. Blue litmus paper is turned red, and if the colors on fibres have been turned green by the action of an alkali, the acid will, as a rule, restore them to the original state. Another method of regarding an acid, which is found of great importance in discussing chemical reaction, is to say that an acid is a salt whose base is water. This definition is very apparent if we regard what takes place in separating the acid from a salt. In this decomposition the acid would appear to be left without having any substitute to take the place of the removed alkali. This is not the case, however, for water is found to enter into the union instead of the base. It can be readily see that every true acid must contain hydrogen; and if this is displaced by a metal, salts are formed directly. The acid can therefore be called a salt whose metal is hydrogen.

A NOVEL AIR PUMP AND VACUUM GAGE

BY THE BERLIN CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

The most indispensable auxiliary of the physicist intent upon investigating those mysterious radiations the study of which is becoming more and more important is doubtless the air pump. For that reason many scientists and engineers have endeavored to improve the existing types of air pumps and have designed novel systems. One of the most interesting is that invented by Dr. Von Reden, of Franzburg, near Hanover.

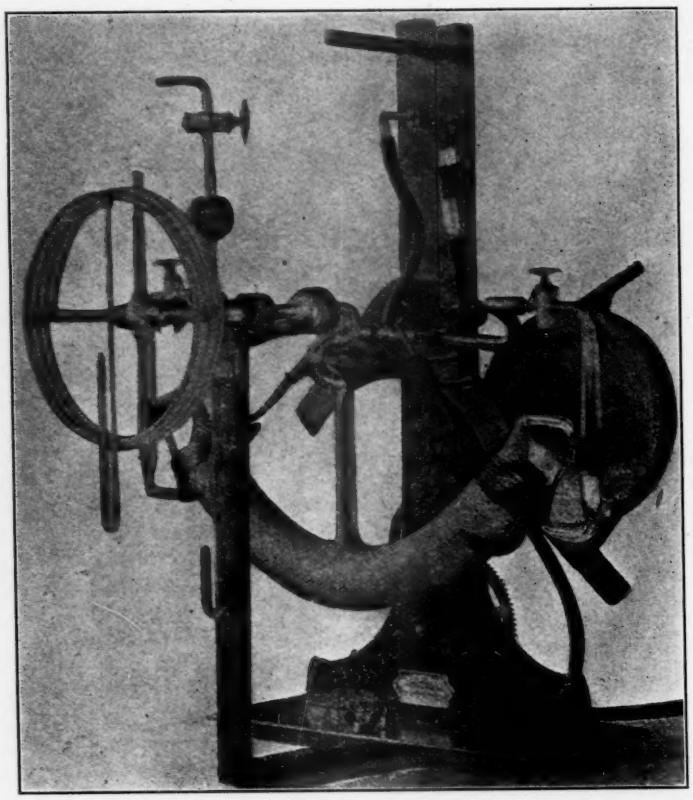


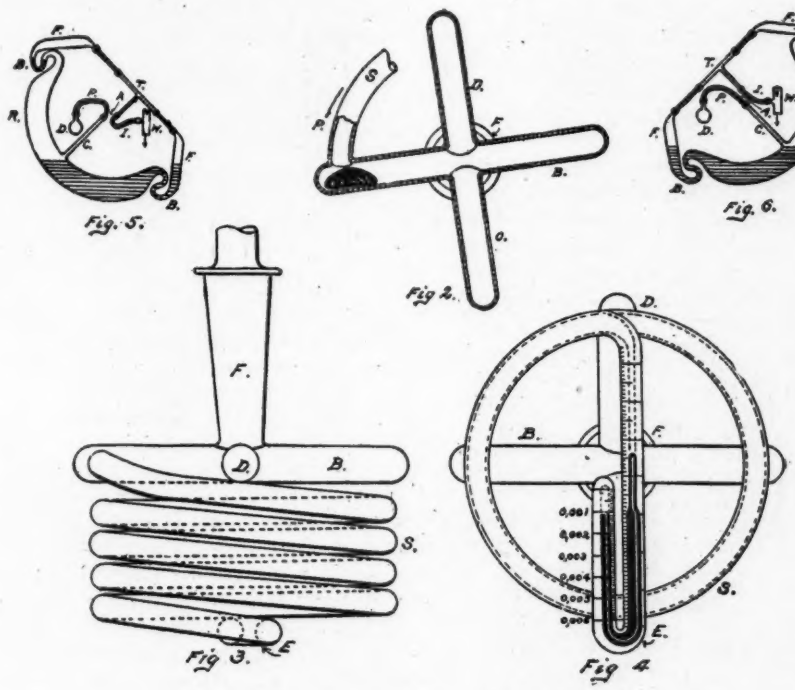
FIG. 1. VON REDEN VACUUM PUMP.

This is a mercury pump, the design of which will be most easily understood by reference to Figs. 5 and 6. The pump consists of a tube filled one-half with mercury, as indicated by the shaded portions. This tube is provided at its two ends with S-shaped tubes *B*, and at its middle with a straight tube *C*.. The S-shaped tubes are connected on both sides to widened portions *F*, connected by rubber tubing with a T-shaped tube and thence by tube *I* with a water supply *W*. The straight tube *C* and the bulb *D* to be exhausted are connected by a rubber tube *P*. The entire apparatus turns round a pivot *A*.

After having produced a preliminary vacuum (of about 20 millimeters of mercury) in the bulb *D*, and the apparatus, by means of the water pump *W*, the apparatus is oscillated from the position represented in Fig. 5 to that of Fig. 6 and back. The mercury remaining in the S-shaped tubes *B* acts as a pressure valve, and prevents the air in the enlarged portions *F* from returning to the tubes *R*. On the other hand, the air entering from the bulbs *D* in both positions through *C* is driven by the mercury toward the widened portions of the apparatus through the right-hand and the left-hand S-shaped tubes respectively, in order to be eventually discharged by the water pump. The connecting tube *P*, which, owing to its

porosity, would not be very efficient, is advantageously replaced by a connection consisting of ground-glass joints in the shape of perforated glass balls, fitting tightly in the carefully polished hemispherical cap, as shown in a halftone illustration, Fig. 1. In order to connect the ball with the cap, metallic springs may be employed.

Fig. 1 represents to the right a turbine belted to a pulley, which oscillates the tube by means of gearing and a crank mechanism. The glass ball joints lead to the spiral vacuum gage and the joint provides a connection with the bulb



DETAILS OF VON REDEN VACUUM PUMP.

to be exhausted. A short-arm manometer is mounted below the bulb.

The pump above described can exhaust within three minutes a bulb of about 500 cubic centimeters capacity (a preliminary vacuum having been previously obtained by means of a water pump) to 1/100 of a millimeter of mercury; in four minutes, to 1/1000; in five minutes, to 1/10,000; and in thirteen minutes, to 1/100,000 millimeter of mercury, the lower handle being turned at the speed of six revolutions per minute. All the air should be expelled from the two vacua *F*, in order to obtain the vacuum last named. This is effected when the pump has been given its maximum inclination by means of the mercury, which on entering the apparatus throws back any residual air through the cocks *H* and *H'*, closed rapidly after the tube *R* has been kept oscillating for seven minutes. The pump is stopped only for a very short time.

The vacuum gage represented in Figs. 2, 3, and 4 consists of a spiral glass tube attached to two cross tubes (Fig. 2). The left-hand tube *B* incloses a small amount of mercury and the cross tubes *B*, *D*, *O* are mounted on a standard ground-glass joint, the conical angle of which is accurately given.

By turning the spiral round on the axis of the joint *G* in the direction of the arrow *P* (Fig. 2) the small amount of mercury represented at the left of Fig. 2 is made to enter the spiral, there compressing the exhausted air, until after a number of revolutions it enters the U-shaped tube *E* of Fig. 4, in order there to occupy the position marked. The left-hand arm of the U-tube is so graduated that the di-

visions 0.001, 0.002, etc., to 0.006, limit 1/1000, 2/1000, etc., to 6/1000 of the total capacity of the U-shaped tube and of the spiral in the upper portion of the capillary tube. The right arm of the U-shaped tube is graduated to millimeters. In the present case, the exhausted air of the spiral is compressed as far as the division 0.001; that is, to 1/1000 of its previous volume; in the right arm of the tube, the mercury takes up a position 16 millimeters higher As, however, the atmospheric pressure in the bulb to be exhausted is 1/1000 of the pressure read on the gage, its value has accurately been 16/1000 millimeter.

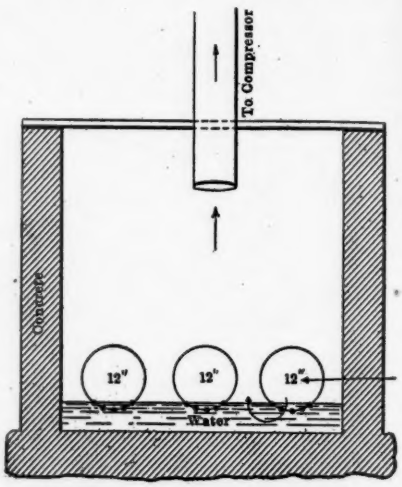
The spiral gage will indicate vacua up to 1/10,000 millimeter. The only distinctive feature of the one used in measuring a vacuum of 1/100,000 millimeter is its being provided with a longer spiral and thinner U-shaped tube.

ATMOSPHERIC HUMIDITY A FACTOR IN EGG PRESERVATION

Notwithstanding the enormous number of eggs consumed in New York it is seldom that an actually "bad" egg is found. The "goodness" of the eggs, however, is a vastly variable quality. The age of the eggs sold may vary from a day to a year, and age tells against them. The "meat" of the egg entirely fills the shell at the beginning, but when it is stored shrinkage by evaporation begins and the longer the egg is kept the smaller will be the bulk within. If an egg is boiled hard the extent of the shrinkage will be indicated by the vacant space usually in the larger end. The United States Department of Agriculture is investigating the various methods of preserving eggs for the purpose of determining which method is most efficacious and works the least injury to the eggs. It has been discovered that the amount of moisture in the air surrounding the egg is an important factor in egg preservation, for which reason the Department is conducting experiments to devise means for regulating the amount and the humidity of the air supplied to eggs kept in cold storage.

WASHING AIR FOR COMPRESSORS

The site of the compressor plant of the Penn Iron Mining Company is on a sandy bottomland at the base of a hill that furnishes more or less sand during windy weather. As the result of these conditions sand would get into the compressors and cause trouble. A scheme for washing the air was resorted to which is shown in the accompanying sketch. A concrete box 5 1-2 ft. wide, 5 ft. high and 16 ft. long was constructed. In the bottom of the box three 12-in. cast iron pipes were laid, extending the full length of the box, their open ends outside the box. The pipe is supported by the end walls. The lower side of the pipe is perforated with



CONCRETE BOX FOR WASHING AIR.

a sufficient number of 1-2-in. holes to allow the air to pass down through the water and up into the box. Water is placed in the box so as to cover the perforations in the pipe 1 in. deep. This, however, is adjustable and can be arranged for any depth necessary.

The box is covered tight with plank so that all the air must enter through the water-covered holes in the 12-in. pipe. The intake pipe from the compressor enters from the top of the box but does not extend to the water. L. F. Armstrong, mechanical engineer for the company, designed this apparatus.—*Engineering and Mining Journal.*

The National Fire Protection Association's Committee on Artificial Refrigeration recommends: That graphite be used as a lubricant in air compressors used in dense air systems and for air compression for purposes other than refrigeration, as the temperature of the compression cylinders undoubtedly rises in some air systems to a point where inflammable vapors may be generated from lubricating oil.

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THE INTAKE PRESSURE IN AIR COMPRESSOR CYLINDERS

We cannot undertake the stunt proposed below by our esteemed correspondent, except in so far as we have done it in the issue immediately proceeding this. It would be a good topic for an engineering student's graduating thesis or for a paper to be buried in the transactions of one of the societies, but on our pages it would be a waste of space, and to many of our readers the computations involved would be an exasperation. We have no monopoly of the theory of the inertia of the air causing the phenomenal filling of the air cylinder at the beginning of the compression stroke. This excess of pressure is attested by indicator cards from compressors of several different types. We think the "ram" theory is a little better than to attribute the occurrence to the heating of the air as it flows into the cylinder or to say that leaky discharge valves or pistons do the trick. We do not know any one in the United States more likely to be able to offer a still better explanation than our present correspondent.

Editor Compressed Air Magazine:

Referring to the article on page 5441 of the October issue of Compressed Air Magazine, I note your remarks concerning the ram effect of the intake air in piston inlet compressors [It is shown also by cards from compressors of other types. Ed. C. A. M.] and inasmuch as this same statement has appeared before in your publication, and has received your endorsement, I believe it would tend to help us all along to a proper recognition of the fact if you would go into the matter a little more in detail and with some figures attached. I would suggest:

First; that you assume a certain size of cylinder and a piston speed best adapted to illustrate your theory.

Second; that you assume some point in the intake stroke where this ram effect begins and thus be able to calculate the velocity of the air in the piston inlet [Why not any other kind of inlet pipe connected to any other compressor? Ed. C. A. M.]

Third; that inasmuch as the air within this piston inlet is the only air that gives the ram effect [Not so. A pipe leading to the actual piston inlet pipe, or a similar pipe leading to

any other compressor should be included. Ed. C. A. M.], its weight and velocity being known, you will then be able to give a value to its kinetic energy in foot-pounds or decimals thereof.

Fourth; knowing the weight of air in the compressor cylinder, you will then be able to calculate to what pressure the foot-pounds of energy in the piston inlet will compress the air in the cylinder, and we will have a result in pounds, ounces, or decimals of either, and thus have something definite while it may not be exactly accurate, and we can then judge if such a result will be sufficient to be noticed by an indicator pencil.

I confess I am puzzled by the last four lines of the article referred to, and cannot see what the quick closing of a valve has to do with it. It would appear that the same effect must be produced when there is a valve there or not, although, of course, the excess pressure produced by the ram would be immediately lost with [We would say without. Ed. C. A. M.] a valve. I hope you will give us figures.

E. A. Rix.

San Francisco.

SEVENTY-FIVE YEARS OF ENGINE BUILDING

A beautifully printed and exceptionally handsome and artistic brochure of fifty pages tells in a most interesting way the story of the beginning, the growth and the present status of the well known steam and gas engine building firm, the C. & G. Cooper Company, Mt. Vernon, Ohio. It is a story of beginning at the beginning, and then of healthy and continuous enlargement and advancement until now the business ranks with that of the great engine building firms of the world, while the character of its product stands also in the foremost rank. The business was founded by Charles and Elias Cooper in 1833, it being first a foundry and a shop whose output was plows, carding machines and special power machinery. Its first engines were of the most primative type. The firm built some locomotives in the early fifties. The first Corliss engines built in the West were designed by this company and placed in service in 1869. Charles Cooper died in 1901 at the age of 92, having retired from active business several years before. The personnel of the company is now in the third generation and it is pleasant to note that the broad original policy continues. The owners manage the business and are in personal touch with both patrons and employees. The company has always shown a personal interest in its men. It has paid them 6 per cent. interest on savings left with it, assisting the men to acquire homes and to become, as so many of them are, permanent and useful citizens of the community. The business has been carried forward through successive periods of depression without interruption, the confidence and good will of patrons and of employees have been held, and the firm stands firmer and higher than ever before in its history.

HIGH PRESSURE GAS DISTRIBUTION

By G. A. Reichard.

Noticing the article on page 5306 in reference to a small high pressure gas distributing system, I would state that the high pressure distribution of gas has been used in this vicinity for some years and I herewith give you a short description of the high pressure gas distributing system of the Los Angeles Gas & Electric Corporation, whose predecessors, the Los Angeles Lighting Company, commenced the high pressure distribution of gas in 1901, installing at that time a horizontal duplex single stage belt-driven compressor with a capacity of about 50,000 cu. ft. per hour.

Since then this system has grown to large proportions, and at present their high pressure distributing lines comprise more than 128 miles of feeders and laterals operating under high pressure, distributing gas to the outlying portions of Los Angeles and to the Cities of Pasadena, Alhambra, Dolgeville and Hollywood.

The compressor station is independent of the main gas manufacturing plant and situated about 1,000 ft. from the same, near the large gas holders. There are four compressors having a total capacity of more than 900,000 cu. ft. per hour or more than 15,000 cu. ft. per minute, as follows.

One 24/42x34x60 Laidlaw-Dunn-Gordon Corliss cross compound non-condensing duplex compressor, with "Cincinnati" air valve gear, having two mechanically moved inlet valves in each head of both compressor cylinders. This machine develops more than 1200 H. P. when operating at its maximum capacity and has a displacement of about 550,000 cu. ft. per hour.

There is also one 25x24 Hall duplex belt-driven compressor belted to a 350 H. P. electric motor, having a displacement of about 150,000 cu. ft. per hour.

One 22x30 Ingersoll Rand horizontal duplex belt-driven compressor belted to a 350 H. P. electric motor, having a displacement of about 148,000 cu. ft. per hour.

One 16x18 Laidlaw-Dunn-Gordon duplex belt-driven compressor belted to a 125 H. P. tandem compound engine having a displacement of about 57,000 cu. ft. per hour.

These machines all have mechanically moved inlet valves. The gas is delivered to the compressors from large gas holders under a pressure of from 6 to 10 inches of water. The entire plant is designed for a working pressure of 60 lb., at which pressure it is operated when working at its maximum capacity. However, when the consumption is light the working pressure is from 25 to 50 lb.

This system is very satisfactory, permitting the manufacture of gas economically in large quantities under excellent conditions, in a large and well equipped central plant. The cost of compression based on actual operating periods and conditions, including operating and fixed charges, is said to be less than 1¾ cents per 1,000 cu. ft.

There are a number of other high pressure gas distributing systems on this Coast but this is the largest and most important that I know of and is operated in connection with the largest crude oil gas manufacturing plant in the world.

THE BELL HUMIDIFIER

In a paper before the National Association of Cotton Manufacturers, Mr. George V. S. Michaelis gave an account of the system of humidification developed by Dr. Louis Bell of Boston, Mr. S. H. Bunnell and others of the Griscom-Spencer Company of New York. The mechanical and sanitary effects of this system depend upon an adequate circulation of properly conditioned air in mill or factory. Warmed fresh air is forced into the mill room by a series of fans, and exhaust fans are used to remove the foul air. Drafts are avoided by a four-sided distribution from the fan outlets through greatly enlarged openings, so that the velocity of the air currents is materially reduced, although remaining adequate to secure a general circulation in the mill room. Heating by pipes is recommended as giving more uniformity than hot blast alone.

The Bell humidifier consists of a rectangular copper case containing 17 sheets of 20x38-in. moistened cloth spaced about 1 in. apart. Each cloth is hemmed at its upper and lower edges, the upper hem being slipped over a slotted brass pipe and the lower end slipped over a tension rod by which the cloth is stretched in position. Water is supplied to the humidifier by a small manifold pipe to which the 17 brass pipes supporting the cloths are connected. In summer cool water is used and the evaporation as well as the contact with the cold sheets tends to decrease the temperature in the mill room. In winter the water must be heated, which may be done by introducing steam into the supply mains, as the cooling effect upon the air otherwise becomes too great, the air after leaving the case being lowered in humidity considerably as it circulates to warmer parts in the room. As the pipes are surrounded by the hem of the cloth, it is impossible for the water to fall clear of the cloth and to be caught in the form of drops in the air current. At the lower edge of the casing there is a gutter formed on the interior walls, by which the drip from the edges of the cloths is caught and conducted out of the path of the air currents.

A disk fan is secured to one side of the casing at the extreme top and is driven either by an independent electric motor or by a light belt. Air is drawn from the mill room into the humidifier casing and forced down between the sheets of cloth, emerging from the bottom of the case, where it is deflected outward evenly on all sides of the machine by a drip pan a short distance below the casing.

THE COST OF THE INTAKE

The necessity of having the air brought to the compressor in a cool, dry, pure state, is not sufficiently appreciated by engineers. As an illustration of the effect of the disregard of this rule the case may be mentioned of a well-known Mexican mine at which otherwise the heads of departments were earnestly working to reduce the operating cost. In this mine an electrically-driven air compressor was erected near the collar of the interior shaft, at a considerable distance from the mouth of the tunnel. The air entering the compressor was, of course, that of the room at the collar of the shaft, heated and vitiated by contact with the

workings in heavy sulphide ores below. At some 10 meters from the compressor are well-ventilated, dry and cool old workings, having a temperature of some 20 degrees below that of the compressor room. A drive of about 5 meters would have made a connection and the cool air so brought to the intake valve of the compressor would have produced an increase of 5 per cent. in efficiency. The annual operating costs of this compressor were: Power, $22,500; direct labor, $2,340; oil, repairs, etc., $564; a total of $25,400, on which an increase of 5 per cent. in efficiency would make a reduction of $1,270.

AIR CYLINDER LUBRICATION

From the valuable pamphlet recently issued by The Fidelity and Casualty Company of New York, on "The Prevention of Industrial Accidents," we reproduce the following relating to the methods, safe and otherwise, of lubricating air compressor cylinders:

Recent disastrous explosions in air-compressor systems present striking examples of the danger existing from the use of ordinary engine oil in the air-cylinders of air-compressors. Only a pure mineral oil, with a flash point as high as good lubricating qualities will permit, should be used. As little as possible of even the best oil should be used. *An excessive amount of oil should be kept out of the system.*

Numerous cylinder oils are compounded, and such oils are likely to produce a carbon that will stick the valves, and collect on the valve-faces and other parts of the cylinder and valve chambers, resulting in a danger condition.

Air-receivers are liable to explosion from accumulated oil deposits. Every receiver should be equipped with a pressure-gauge, a safety-valve, and proper drains, and all reservoirs and likely places of deposit in the air line should be thoroughly and frequently drained and cleaned. It is bad practice to have the inlet of an air compressor take from a hot or dusty room,—the air should be cool and as clean as possible.

The practice of throwing kerosene oil into the inlet of an air-compressor to clean it is an extremely dangerous one, and the cause of an explosion under such circumstances is not difficult to understand. Lubrication of the air-cylinder with soapsuds (preferably made of soft soap, about one part soap to fifteen parts water) for a few hours each week (or less frequently if the load is light), instead of oil, will help very materially in keeping the cylinder clean. The only danger from the use of soapsuds is rust, and this should be overcome by being careful to discard the soap and feed the cylinder with oil an hour or so before shutting down. The receiver blow-off should then be opened and the accumulation of oil and water drained off.

An air-compressor engine should not be controlled by the air pressure alone, as many are, but should be fitted with an auxiliary governor which will act as soon as the speed rises above a certain predetermined limit. This will prevent the engine from "racing," in case an accident to the tanks or piping causes a sudden lowering of the pressure. It is not necessary for an explosion to take place to produce a lowering of the pressure, as the giving way of a pipe, valve, or tank from any cause will have the same effect.

The steel used in the construction of air-receivers should be of the best quality and should have a tensile strength of from 55,000 to 62,000 pounds per square inch. The side seams should be double-riveted, or better still be butt-strapped. The heads should be dished. The larger sizes of receivers should be provided with man-holes.

THE QUESTION OF THE ELECTRIC DRIVE

During the last few years the question of the best method of driving cotton mills has been brought into prominence by the claims which electrical engineers have put forward for the electric drive. The advantages claimed for electricity have sometimes been demonstrated by comparing a brand new factory with electric driving with a more ancient one in which steam power alone is used. When the Special Committee of Inquiry of the Bradford Engineering Society was formed some two years ago to investigate and report on the subject, millowners felt that they would at last obtain some reliable information to guide them in future installations. The Committee appointed as its chairman Professor G. F. Charnock, and embraced a number of gentlemen of recognized ability, both in mechanical and electrical engineering. Its preliminary report, issued in October, will not encourage factory managers

to scrap direct mechanical drives in favour of electric motors. The Committee decided first of all to carry out certain experiments, with the object of determining the actual cyclical variation occuring in prime movers and electric motors, and also in shafting and machinery driven by them. After exhaustive trials carried out in mills, in which various driving conditions existed, the Committee have come to the conclusion that "in good installations there is practically no difference in cyclical variation between mechanical and electrical transmission when measured at the end nearest the main drive." The report even pronounces further in favour of mechanical transmission, by stating that there is less loss in this case in modern mills of ordinary dimensions where the power is generated on site.—*The Engineer.*

COMPRESSED AIR INFORMATION

The following (with our italics) is the concluding paragraph of a three column article in a Western paper about air receivers:

It is seldom practical to "re-heat" air in mining. But after the air is dried, re-heating increases the expansion and efficiency, *and even raises the temperature* so that it prevents freezing, and where practical this is not intended to belittle the value or importance of re-heating.

SMOKE AND FOG IN CITIES

Increasing attention is being given in German cities to all questions connected with atmospheric conditions. The fact that sunshine lessens as population becomes more dense, and especially when the activity of industrial centres expands superficially and increases in intensity, has long been noted. An increasing tendency to fog has also been observed, and both are effects of the imperfect and incomplete combustion of coal. Modern industry pays toll for this in the injury to delicate fabrics, the general depreciation in the value of many articles of trade and household use, and the increased cost of cleansing. Since the battle is waged with growing energy against tuberculosis, physicians and students of social science feel that the problem of purer air for the dwellers in cities has become one of prime importance. Statistics have been collected for some time past, which demonstrate how little sunshine falls to the lot of the residents of industrial cities, even when the sun is unobscured by smoke particles. In no German city has the loss of sunshine due to fog yet equalled that of London, where the foggy days during the three months, December, January, and February, increased from eighteen to thirty-one during the last half of the past century.

NOTES

We frequently have inquiries concerning the raising and transportation of grain by compressed air. Specific information as to what is actually being done in this line will be welcome.

An aeroplane flight of 144 miles in 4 hrs. 6 min. 25 sec. was made at Mourmelon, France, on Nov. 3, by Henry Farman. This flight was in competition for the 1909 Michelin cup, which was won in 1908 by Wilbur Wright in a two hour flight, and is the best endurance record yet made.

A German medical journal describes five recent cases of inquiry inflicted upon the eyes by the rays of mercury vapor lamps. These cases, in connection with others previously reported, leave no room for doubt that the light of the mercury vapor lamps employed in therapeutics and for the illumination of factories and other buildings may injure the eyes, not only by causing conjunctivits (inflammation of the lining membrane of the eyeball) but also by producing paralysis of the retina.

Prof. E. A. Watson, of the University of Liverpool, describes an experimental investigation of the dielectric strength of air. The potential difference necessary to cause a spark to pass between two small metal spheres at various distances apart, in air, was carefully measured, at air pressures between one and fifteen atmospheres. At the latter pressure it was found that air will stand an electrical stress of 40,000 volts per millimetre, a fact which may soon find an application in apparatus where high insulation is required.

It is well understood that an ordinary suction pump can draw water from a depth of 34 feet at the most, in practice falling short of this. A French machinist has found that by running a small tube open to the atmosphere

down into the well and entering the suction pipe with a tight joint, the end of this pipe being curved to point upward in the water, it is possible by working the pump rapidly to lift water as high as 65 feet. Both the speed of working and the air admission require to be carefully adjusted.

The McMillan Pump, Power & Mfg. Company proposes to build at Kansas City, Kan., a free workshop for inventors whose ideas are seen to possess merit. The building will be 75 x200 ft., two stories, constructed of cement. The second floor of the building will be set aside for inventors who take advantage of the offer. The idea originated with Milton McMillan, the president of the company, whose early history as an inventor had taught him that many good devices are lost to the world because their inventors are handicapped by lack of the necessary funds to produce them.

A Ladder Dredge capable of excavating to a depth of 46 ft. below water level in hard material has been built in England for use in the port improvements at Para, Brazil. The dredging engines required for the chain of buckets aggregate 600 hp. and are mounted near the top tumbler, with their gearing designed to act as directly as possible upon the buckets so as to increase the efficiency when working in the hard material. The shaft of the tumbler over which the buckets turn at the top is of solid steel, 19 1-2 in. in diameter. The dredger will operate in conjunction with large hopper barges.

Three employees of the Penn Iron and Coal Company, Canal Dover, O., were crushed to death in the cylinder of a 160-ton blowing engine. The inside of the cylinder was four feet in diameter and the men were working with their feet against the piston end. The piston was being held back by a brake against the 30-ton flywheel. Suddenly the brake slipped and the wheel, impelled by a many-ton counter-balancing weight on one side, turned over. The piston crushed the three men into a space three inches deep and four feet in diameter, between the piston and cylinder head.

An interesting thing in the mushroom line came to light recently when a giant specimen weighing over thirty pounds was found near Pittsburg by one of the professors in the Carnegie School. The mushroom was edible, it was found, and though it may not have been the growth of a night, it certainly grew in less than forty-eight hours, since a search of its locality made the day previous to that on which it was found disclosed no evidence of it. If mushroom growers could arrange to cultivate this particular species, more than one mushroom fortune might be the result.

That the submarine bell is valuable in preventing delay of ocean liners by fog has recently been proved in the case of the "Lucania" and the "Kaiser Wilhelm der Grosse." The former vessel, while approaching New York, was enabled to make the light vessel by submarine bell signals, these being her sole guide. The captain of the "Kaiser Wilhelm der Grosse" when on an eastern passage was shut in by dense fog near Fire Island light vessel. He was able to hear the submarine bell and direct his course accordingly, although he was twelve nautical miles distant from the signal station. At the same time the fog horn of the lightship was quite inaudible.

Since there is no tide in the Mediterranean, the inhabitants of Marseilles were greatly astonished on June 15th, when the water of the harbor began suddenly to oscillate, and continued in movement for a quarter of an hour. Some observers say that the first waves were about two and a half feet in height, but others put their height at half that amount. Many thought that the cause was an earthquake, but Mons. Louis Fabry, after a study of the phenomenon, ascribes it to a sudden increase of the barometric pressure of the air on the surface of the sea in the neighborhood of Marseilles. The puzzling question remains, What produced the sudden increase of barometric pressure?

The use of the sand blast for polishing metals is being superseded now by a blast of simple hot air. It is the velocity that gives the polishing power. The articles to be treated are placed in a basket in a centrifugal machine driven at a very high speed, and heated air is blown from a pipe through the basket. A high polish is thus produced very rapidly. Nickel-plated articles that have become tarnished are made bright in a few minutes. Wet metal,

fresh from the bath, needs no preliminary drying, for the current of air dries and polishes at the same moment. It is only necessary to so pack the articles that the air reaches them on all sides.

In a gassy mine where it is considered dangerous to convey electric current to the coal face, the general power advocated in such cases is compressed air. This does not mean, however, that the compressors should be located on the surface, but rather that advantage should be taken of the cheapness and efficiency of electricity as a distributing agent, consequently installing the compressor plant at the shaft bottom, or as near the face as electric current can be safely conveyed.

A phonographic safe-lock has been invented which it is claimed can be opened only by the owner. Tests in the presence of experts seem to substantiate the inventor's claims. Instead of a knob on the door there is the mouthpiece of a telephone. A delicate needle is attached to the diaphragm, the end of the needle resting in a groove of a sound record made on a phonograph cylinder. The word which the safe is locked on is thus recorded, and the one who uttered it must repeat it before the safe will open. In the tests a dozen men tried to imitate the voice of the man who locked the safe, but the lock would respond only to the right man.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

OCTOBER 5.

935,634. PNEUMATIC HAMMER. WILLIAM BAXTER, Jr., Jersey City, N. J.

935,655. GASEOUS-FLUID COMPRESSOR. DAVID E. HAIRE, Philadelphia, Pa.

935,684. GASEOUS-FUEL-BURNER WELDING-TORCH. GILMAN PETERSON, Orfordville, Wis., and EUGENE M. BOURNONVILLE, Jersey City, N. J.

935,735. ACETYLENE-GAS BURNER. ARTHUR BRAY, Leeds, England.

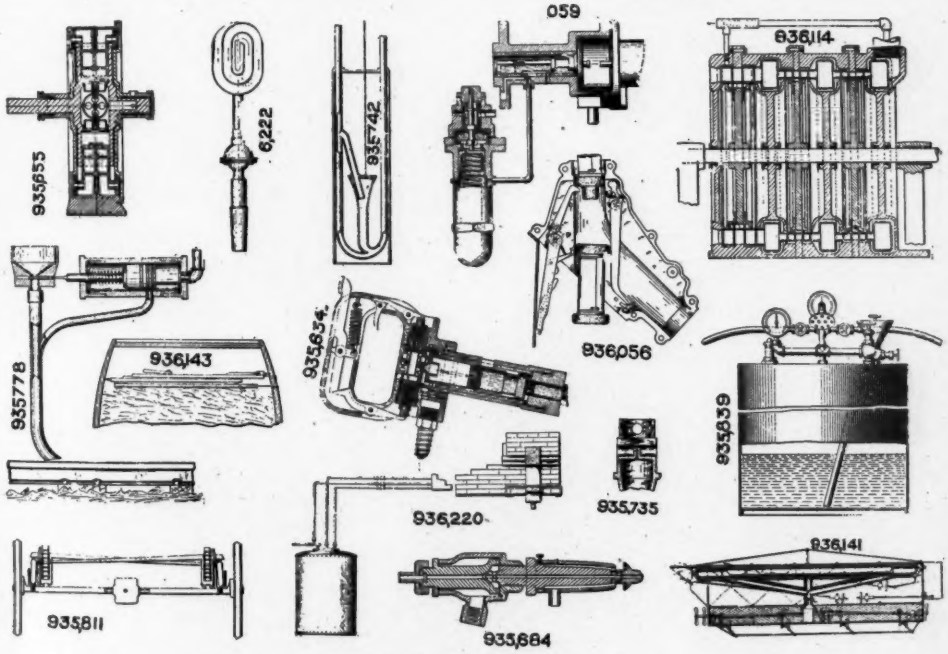
935,742. COMPRESSED-AIR WATER-ELEVATOR. HENRY E. CHLEBORAD, Atwood, Kans.

935,778. TRACK-SANDER. FRANK W. COLE, San Francisco, Cal.

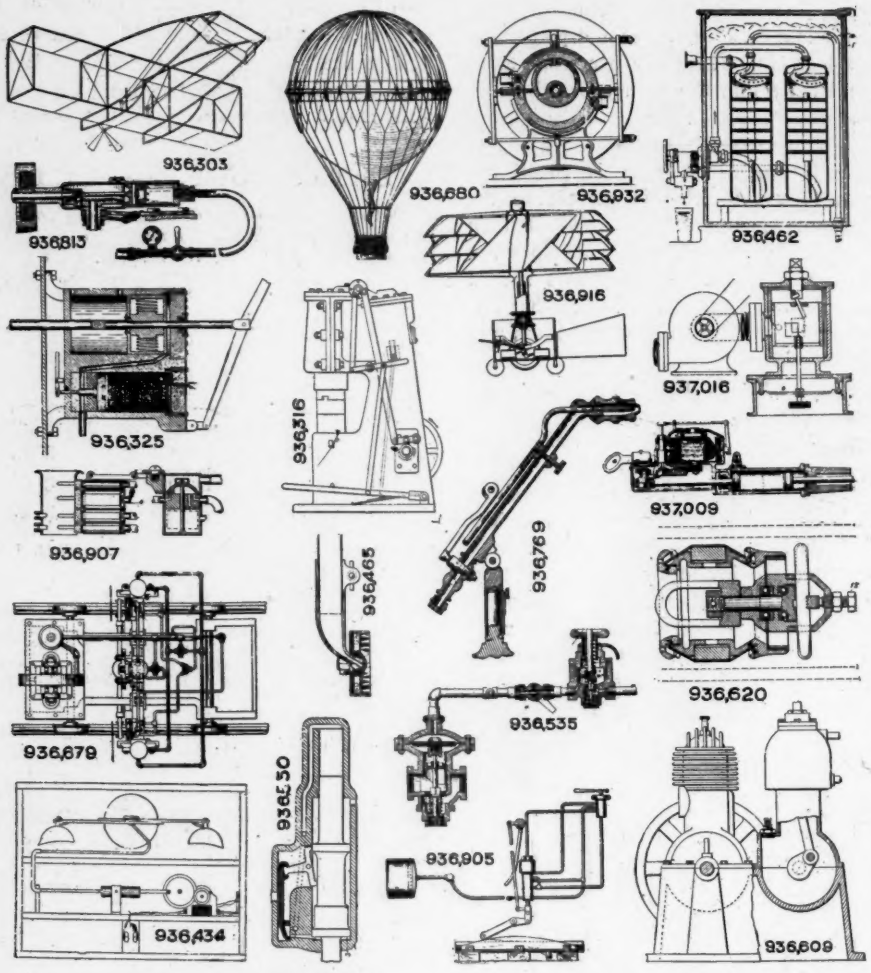
938,811. PNEUMATIC VEHICLE-GEAR. LOUIS J. PERKINS, Lewiston, Idaho.

935,839. EMBALMING APPARATUS. JUAN E. COPPOLA, Mexico, Mexico.

1. An apparatus of the class described, comprising a reservoir adapted to contain an embalming fluid, means for introducing compressed air into the upper part of said reservoir, a pipe leading from the lower part of said reservoir and adapted to lead off the embalming fluid, a valve for regulating the flow from said pipe, a plurality of trocars, and tubes connecting said trocars with said valve.



PNEUMATIC PATENTS OCTOBER 5.



PNEUMATIC PATENTS OCTOBER 12.

935,862. AEROPLANE. ALFRED W. REINOEHL, Philadelphia, Pa.

936,055. TROLLEY-GUARD. SAMUEL STROUP, Peru, Ind.

936,056. PNEUMATIC-DESPATCH APPARATUS. FRED R. TAISEY, Indianapolis, Ind.

936,114. AIR-COMPRESSOR. FREDERICK W. GARDNER, New London, N. H.

936,141. AIR-SHIP. ADOLPH E. G. LUBKE, San Francisco, Cal.

936,143. COMPRESSOR. WILLIAM H. MILLER, Independence, Mo.

936,222. PNEUMATIC CLEANING-TOOL. CHARLES B. DALZELL, Little Falls, N. Y.

936,220. WELDING OIL-BURNER. BREWSTER W. CRIBB, Baltimore, Md.

OCTOBER 12.

936,303. AEROPLANE. CHARLES W. CHENEY, Brookline, Mass.

936,316. PNEUMATIC HAMMER. WILLIAM GRAHAM, Westminster, London, England.

1. A pneumatic hammer having in combination a tup and tup chamber, a reciprocating pump working in a separate pump chamber, connecting means between said pump and tup chambers, means for closing said connecting means, and means acting automatically to cause a lag between said pump and tup pistons after a blow has been struck until the pump piston has moved outward a predetermined portion of its stroke.

936,325. MEANS FOR CONTROLLING THE MOVEMENT OF RAILWAY-VEHICLES. JOHN H. JUST, Syracuse, N. Y.

936,415. AIR-BRAKE SYSTEM. GEORGE E. CONGDON, Jacksonville, N. Y.

936,434. BUST-DEVELOPER. JOHN G. EGANHOUSE, Houston, Tex.

936,462. APPARATUS FOR DISPENSING GAS-IMPREGNATED LIQUIDS. MORRIS J. LEVIN, Providence, R. I.

936,465. VACUUM-SWEEPER. FRANK J. MATCHETTE and CHARLES MOUKOS, Milwaukee, Wis.

936,535. AIR-CONTROL STEAM-VALVE. JAMES A. HICKS, Atlanta, Ga.

936,550. PERCUSSIVE MACHINE AND TOOL. WILHELM MAUSS, Brakpan, Transvaal.

936,609. AIR-COMPRESSOR. JOSEPH H. DAILEY, Wilson, N. Y.

936,620. TUBE-CLEANING APPARATUS. JOHANN G. FRERICHS, Hanover, Germany.

936,679. TRACK-LAYING APPARATUS. RICHARD C. SPANDAU, Danville, Ill.,

1. In a track-laying apparatus, a support, a pneumatically-operated hammer movable bodily up and down upon said support, pneumatic means for operating said hammer, and means for simultaneously lowering said hammer bodily so that the hammer will follow a spike during the driving operation to keep the hammer in position for driving the spike, substantially as set forth.

936,680. BALLOON. JOSEPH A. STEINMETZ, Philadelphia, Pa.

936,710. FOLDING MECHANISM. SAMUEL G. GOSS, Chicago, Ill.

1. The combination with folding rolls, a moving carrier adapted to engage a sheet of paper and forward it into folding position with reference to said folding rolls, and a compressed air supply, of a discharge pipe mounted on said carrier and adapted to discharge a sheet of air between said folding rolls, connections between said discharge pipe and said compressed air supply, and automatically-operating valve mechanism adapted to open the connections to said discharge pipe when said sheet is in position to be folded and then to automatically close said connections..

936,711. PNEUMATIC FOLDING MECHANISM FOR PRINTING-PRESSES. SAMUEL G. GOSS, Chicago, Ill.

936,769. BLOWPIPE. JAMES H. FLOWER, Ashtabula, Ohio.

936,813. AIR-COMPRESSOR. EDWARD J. ROHRBACHER, Blaine, Wash.

936,905. AUTOMATIC BRAKE-APPLYING DEVICE. EARL P. JESSOP, U. S. Navy.

936,907. MILKING-MACHINE. GUSTAF E. JONSON, Hjerpas, Sweden.

936,916. PROPELLER MECHANISM FOR AIRSHIPS. CHARLES M. LEE, Gibbon, Nebr.

936,932. AIR-COMPRESSOR. ARTHUR NEUMANN, St. Louis, Mo.

937,009. PRESSURE-DRIVEN RECIPROCATING TOOL. ALEXANDER PALMROS, Syracuse, N. Y.

937,016. MECHANISM FOR THE PRODUCTION OF A CONSTANT MIXTURE OF GAS AND AIR. FRIEDRICH W. WOLFF, Berlin, Germany.

OCTOBER 19.

937,159. AERATOR. LENA E. LEACH, Venice, Cal.

937,187. AIR SHIP. BENJAMIN F. SEYMOUR, Denver, Colo.

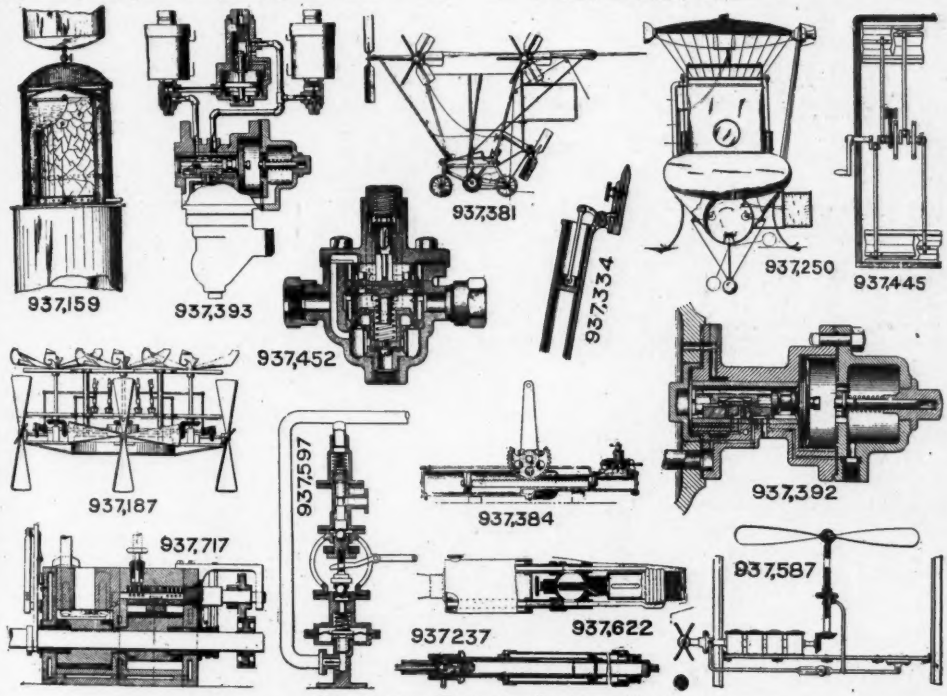
937,237. ROCK-DRILLING MACHINE. JAMES E. H. GROSE, Germiston, Transvaal.

937,250. AERIAL NAVIGATION. JEREMIAH S. LETTS, Dickinson, N. D.

937,334. PNEUMATIC CLIPPER. CHARLES SHURTLEFF, Akron, Ohio.

937,381. MOTOR-DRIVEN AEROPLANE. AUGUST E. MUELLER, Chicago, Ill.

937,384. FLUID-PRESSURE MOTOR. JOHN E. OSMER, Chicago, Ill.



PNEUMATIC PATENTS OCTOBER 19.

937,392. FLUID-PRESSURE BRAKE. WALTER V. TURNER, Wilkinsburg, and JOHN S. CUSTER, Pittsburg, Pa.

937,393. ELECTRIC FLUID - PRESSURE BRAKE. WALTER V. TURNER, Wilkinsburg and ROBERT H. BLACKALL, Edgewood Park, Pa.

937,445. PNEUMATIC MUSICAL INSTRUMENT. EUGENE DE KLEIST, North Tonawanda, N. Y.

937,452. AIR-BRAKE SYSTEM. GEORGE MACLOSKIE, Schenectady, N. Y.

937,587. AEROPLANE. DAVID S. FOSTER, Syracuse, N. Y.

937,597. SAFETY-VALVE FOR STEAM, COMPRESSED AIR OR GAS. GEORG GRUSSENDORF, Hanover, Germany.

937,622. BLOW-TORCH AND SOLDERING-IRON. FRANK J. MANN, New York, N. Y.

937,717. INTERNAL-COMBUSTION AND AIR-

COMPRESSING ENGINE. WARD RISLEY, Jacksboro, Tex.

937,721. FLUID-PRESSURE REGULATOR. EDUARD SCHULTE, Hamon, Westphalia, Germany.

OCTOBER 26.

937,757. AIR-PUMP FOR BLOW-TORCHES. OTTO BERNZ, Newark, N. J.

937,789. MILKING APPARATUS. EZRA E. GOOD, Waterloo, Iowa.

937,790. PUMP. CARL R. GREEN, Dayton, Ohio.

937,827. FRESH-AIR-SUPPLY DEVICE. FRANK S. LIPPITT, Cleveland, Ohio.

937,839. AIR-BRAKE. LORENZO E. MOREL, St. Hyacinthe, Quebec, Canada.

937,872. ROCK-DRILLING MACHINE OR ENGINE. LEWIS L. SCOTT, Joplin, Mo.

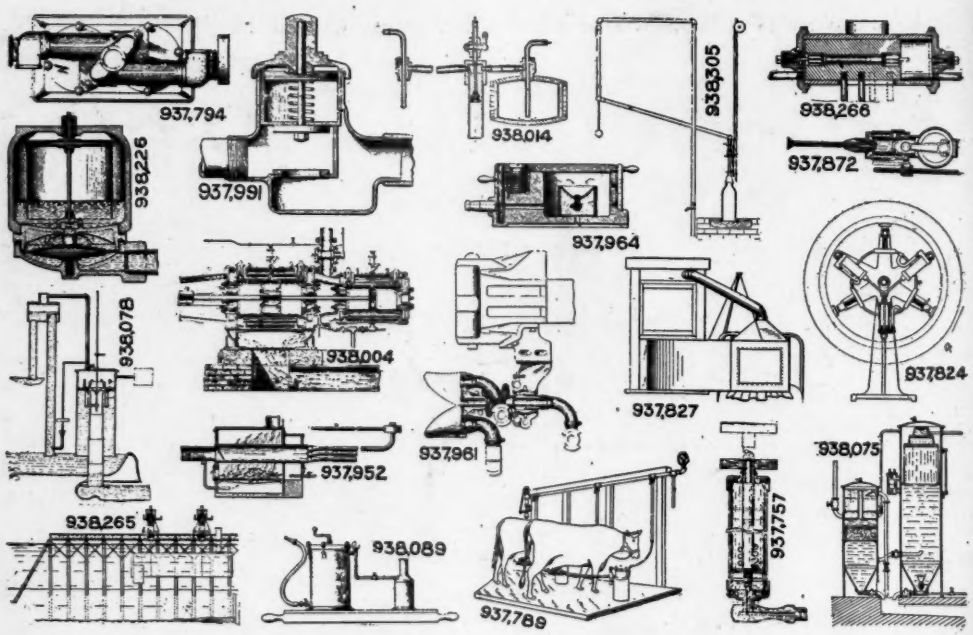
937,884. MEANS FOR HOLDING AND INFLATING PNEUMATIC TIRES. FREDERICK W. STANLEY, Grange-over-Sands, England.

938,014. PNEUMATIC SIPHONING SYSTEM FOR CIRCULATING AIR THROUGH BARRELS. JEREMIAH F. MCLAIN, St. Joseph, Mo.

938,075. WATER-PURIFYING APPARATUS. HANS REISERT, Cologne, Germany.

1. In a water elevator, in combination with a plurality of tanks provided with passages for the entrance thereinto of water by gravity, a pipe adapted to convey air under pressure into said tanks, a controlling valve adapted to shift the air into either of said tanks, and to simultaneously provide an exhaust outlet from another of said tanks, an air driven valve actuator adapted to shift said controlling valve, said valve actuator being provided with an air driven piston and a pilot valve carried by said piston adapted to control a discharge passage for the air used to drive said piston, substantially as described.

938,078. APPARATUS FOR ELEVATING WATER. OLAF A. ROED, Minneapolis, Minn.



PNEUMATIC PATENTS OCTOBER 26.

937,952. MEANS FOR OVERCOMING FROST. HARLEY A. HARDINGE, Los Gatos, and EDWARD A. PAGEL, Campbell, Cal.

The combination of a stationary furnace, an air tube leading therethrough, a plurality of nozzles, a blower for each nozzle, a connection from said air tube to each blower, independent valves for said connections, and an air supply tube for the furnace, the inlet end of said air supply tube being located within the inlet end of the air tube and pointing in the same direction, substantially as described.

937,961. AUTOMATIC AIR AND STEAM COUPLING. JOSEPH V. ROBINSON, Salem, Oreg.

937,964. MEANS FOR MAKING CASTINGS BY AIR-PRESSURE. ORRIN J. SAYERS, Cleveland, Ohio.

937,991. AIR-BRAKE SAFETY-VALVE. ORLANDO GIBSON, Hollidaysburg, Pa.

938,004. COMBINED AIR COMPRESSOR AND INTER-COOLER. JOHN G. LEYNER, Denver, Colo.

938,84. SPRAYING APPARATUS. ARTHUR G. STOUT, South Haven, Mich.

938,144. SPRAYER. EDWARD HARRY, Buffalo, N. Y.

938,226. VACUUM AIR-VALVE. CLAYTON A. DUNHAM, Marshalltown, Iowa.

938,265. SUBAQUEOUS TUNNEL. ERNEST W. MOIR, London, England.

938,266. WATER-ELEVATOR. JOHN MONTGOMERY, Toronto, Ontario, Canada.

3. In a water-purifying apparatus, the combination of a mixing chamber having a water-supply inlet and an air-inlet for supplying air thereto under pressure, means for converting the water into a finely-divided state, a settling-chamber connected with said mixing chamber and having an outlet therefrom, and an automatic regulator for decreasing the pressure when the water in the mixing chamber reaches a certain level.

938,305. AUTOMATIC AIR-VALVE MECHANISM FOR GLASS-DRAWING APPARATUS. HENRY DOUCHAMP, Smethport, Pa.